A21

The Kent Incorporated Society for Promoting Experiments in Horticulture

IMPERIAL MYCOLOGICAL INSTITUTE
27 JUNE 1938

ANNUAL REPORT

(TWENTY-FIFTH YEAR)

1937

EAST MALLING RESEARCH STATION

EAST MALLING
KENT

1st January, 1937 to 31st December, 1937

Free to Associate Members
Price to Non-Members :—
5/- post free
Great Britain only

Published
May, 1938

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(TWENTY-FIFTH YEAR)

1937

EAST MALLING
RESEARCH STATION
EAST MALLING
KENT

1st January, 1937, to 31st December, 1937

Published May, 1938

PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS
109 KINGSWAY, LONDON, W.C.2; AND ASHFORD, KENT

CONTENTS

PAGE

GOVERNING MEMBERS OF THE SOCIETY 5

MEMBERS OF THE EXECUTIVE COMMITTEE 7

STAFF 8

EDITORIAL 11

SECTION I

THE EXPERIMENTAL FARM 13

SECTION II

GENERAL REVIEW OF RESEARCH WORK, WITH SUMMARIES OF PAPERS PUBLISHED DURING THE YEAR 35

SECTION III

PRELIMINARY RESEARCH REPORTS 103

POMOLOGY

The Wild Fruit Trees of the Caucasus and Turkestan. Their Potentialities as Rootstocks for Apples and Pears. I. A First Report on some Wild Quince from the Caucasus. H. M. TYDEMAN 103

The Influence of Different Pollens on the Growth and Development of the Fruit in Apples and Pears. I. A Progress Report on Experiments carried out during 1937. H. M. TYDEMAN 117

Studies in the Non-setting of Pears. II. The Effect of Weather Conditions. D. N. SRIVASTAVA 128

Studies in the Non-setting of Pears. III. The Effect of the Flower Characters. D. N. SRIVASTAVA 145

Studies in Incompatibility of Stock and Scion. II. The Relation between Time of Budding and Stock-Scion Compatibility. R. J. GARNER and D. H. HAMMOND 154

Weather Conditions during 1937. H. C. CHAPELOW and H. M. TYDEMAN .. 158

PAGE

HOPS

A Review of Hop Investigations at East Malling. F. H. BEARD 161

Prices obtained for certain New Varieties of Hops, 1931-1937. F. H. BEARD 166

STATISTICS AND RECORDS

Experiments in Sampling Technique. II. Size and Colour of Allington Pippin Apple, 1936 Crop. T. N. HOBLYN and J. L. EDGAR 168

PHYSIOLOGY

Preliminary Observations on the Carbohydrate Content of Apple Leaves on Different Rootstocks. E. R. LEONARD 173

MYCOLOGY AND BACTERIOLOGY

Notes on Plant Diseases in 1937. H. WORMALD and R. V. HARRIS .. 181

The Crown Gall Disease of Nursery Stocks. III. A Progress Report on Experiments from 1929 to 1937 to determine the Relative Susceptibility of Malling Apple Stocks and including the Production of Galls by Synthetic Growth Substances. R. V. HARRIS and H. L. PEARSE .. 187

Manurial Trial on Nursery Trees with Reference to Effect on Plum Bacterial Canker. H. WORMALD and R. J. GARNER 194

Two Ornamental Shrubs as Hosts of the Organism Causing Plum Bacterial Canker. H. WORMALD 198

A Bibliographical Note on the Distinction between Mild and Severe Strawberry Crinkle. R. V. HARRIS 201

ENTOMOLOGY

Notes on Some Interesting Insects Observed on Fruit Trees in 1937. A. M. MASSEE 203

Notes on the Strawberry Aphid (*Capitophorus fragariae* Theob.). A. M. MASSEE, R. M. GREENSLADE and A. J. DUARTE 209

Studies of Impregnated Tree Banding Materials. IV. Apple Blossom Weevil and Codling Moth Experiments in 1937. A. M. MASSEE, R. M. GREENSLADE and A. J. DUARTE 213

PAGE

INSECTICIDES AND FUNGICIDES

Spray Residue Investigations. II. The Influence of Spray Supplements on the Retention of Lead Arsenate on Apples. H. SHAW and W. STEER .. 219

Experiments in the Control of Plum Sawfly on Czar Plums. W. STEER and A. A. G. HASSAN 223

Field Trials in 1937 of the Fungicidal and Phytocidal Properties of Certain Sprays used against Apple Scab. A Progress Report. M. H. MOORE .. 229

SECTION IV

BULLETINS FOR FRUITGROWERS 237

POMOLOGY

Winter Pruning of Apple Trees. Some Advice based on the East Malling Experiments. N. H. GRUBB 237

The Frameworking of Fruit Trees. R. J. GARNER and W. F. WALKER .. 242

MYCOLOGY AND BACTERIOLOGY

Verticillium Wilt of Hops. A Summary of Information for Growers. R. V. HARRIS and B. S. FURNEAUX 257

WALNUTS

A Survey of the Investigations on the Propagation and Testing of Walnuts at the East Malling Research Station. A. W. WITT 259

Digitized by the Internet Archive
in 2025

https://archive.org/details/report-east-malling-research-station_1937

GOVERNING MEMBERS OF THE SOCIETY

(Appointed under the Revised Articles of Association, June 1936)

Appointed by the Ministry of Agriculture:

Sir FREDERICK W. KEEBLE, Kt., C.B.E., D.Sc., F.R.S., Cedron House, Fowey, Cornwall.

Appointed by the Kent County Council:

ED. HARDY, Esq., C.C., Boughton Court, Ashford, Kent.

Sir OSMOND E. D'AVIGDOR GOLDSMID, Bt., D.L., J.P., M.A., LL.B., Somerhill, Tonbridge, Kent.

W. J. THOMAS, Esq., Brownings, Rodmersham, Kent.

Appointed by the Surrey County Council:

S. S. BOORMAN, Esq., Heath Farm, Send, Woking, Surrey.

Appointed by the East Sussex County Council:

E. S. ATTRELL, Esq., Warren Fruit Farm, North Common, Chailey, Sussex.

Appointed by the West Sussex County Council:

Gen. Sir IVOR MAXSE, K.C.B., C.V.O., D.S.O., F.R.G.S., Little Bognor, Fittleworth, Sussex.

Appointed by the Council of the Senate of the University of Cambridge:

Professor Sir ROWLAND H. BIFFEN, M.A., F.R.S., School of Agriculture, Cambridge.

Appointed by the Senate of the University of London:

Professor Dame HELEN GWYNNE-VAUGHAN, G.B.E., D.Sc., LL.D., F.L.S., 93 Bedford Court Mansions, London, W.C.1.

Appointed by the University of Bristol:

Professor B. T. P. BARKER, M.A., The Research Station, Long Ashton, near Bristol.

Appointed by the Governing Body of the Imperial College of Science and Technology:

Professor V. H. BLACKMAN, Sc.D., F.L.S., F.R.S., Imperial College, South Kensington, London, S.W.7.

Appointed by the Council of the Royal Society:

Professor E. J. SALISBURY, D.Sc., F.L.S., F.R.S., University College, Gower Street, London, W.C.1.

Appointed by the Governors of the South-Eastern Agricultural College, Wye:

ED. HARDY, Esq., C.C., Boughton Court, Ashford, Kent.

Rt. Hon. Lord NORTHBOURNE, C.C., Northbourne Court, Deal, Kent.

Appointed by the Research and Advisory Committee of the South-Eastern Agricultural College, Wye:

R. M. WILSON, Esq., B.Sc.Agric., South-Eastern Agricultural College, Wye, Kent.

Appointed by the Governors of John Innes Horticultural Institution:

Sir DANIEL HALL, K.C.B., M.A., F.R.S., LL.D., John Innes Horticultural Institute, Merton, Surrey.

Appointed by the Council of the Royal Horticultural Society:

E. A. BUNYARD, Esq., F.L.S., The Royal Nurseries, The Broadway, Maidstone, Kent.

Appointed by the Council of the Institute of Brewing:

C. E. W. CHARRINGTON, Esq., 16 Southwark Street, London, S.E.1.

Appointed by the Research Fund Committee of the Institute of Brewing:

G. T. COOK, Esq., Queen's Avenue, Maidstone, Kent.

Appointed by the National Farmers' Union (Central Council, London):

J. S. CHIVERS, Esq., Messrs. Chivers & Sons, Ltd., Histon, Cambridge.

J. E. SANDALL, Esq., Beechwood, Clarkson Avenue, Wisbech, Cambs.

Appointed by the National Farmers' Union (Kent Branch):

A. AMOS, Esq., Spring Grove Farm, Wye, Kent.

ALFRED DAY, Esq., J.P., Great Tong Farm, Headcorn, Kent.

B. R. DIXON, Esq., Cambridge, Greenstreet, Sittingbourne, Kent. (*Deceased November*, 1937.)

S. R. DIXON, Esq., Cambridge, Teynham, Sittingbourne, Kent. (*Appointed January*, 1938.)

W. T. EDMONDS, Esq., Allington Farm, Maidstone, Kent.

P. MANWARING, Esq., J.P., Crossway, Knole Paddock, Sevenoaks, Kent.

Sir AMBERSON B. MARTEN, Kt., M.A., LL.D., Gedges, Matfield, Paddock Wood, Kent.

D. J. MOOR, Esq., Nichol Farm, Teynham, Kent.

S. W. MOUNT, Esq., Hode Farm, Patrixbourne, Canterbury, Kent.

T. NEAME, Esq., The Offices, Macknade, Faversham, Kent.

J. A. RAYNHAM, Esq., Dairy Farm, Marden, Kent.

J. M. ROBERTSON, Esq., Beluncle, Hoo, Rochester, Kent.

J. F. TOWNER, Esq., Salts Farm, Loose, near Maidstone, Kent.

Appointed by the Council of the Horticultural Trades' Association:

L. J. COOK, Esq., 7 Drapers Road, Enfield, Middlesex.

Appointed by the Associate Members of East Malling Research Station:

Capt. R. WELLINGTON, Worth, Hele, Bradninch, S.O., Devon.

A. T. MILLER, Esq., Wested Farm, Swanley, Kent.

MEMBERS OF THE EXECUTIVE COMMITTEE

(Governing Members elected at the General Meeting, June 1936)

Professor B. T. P. Barker, M.A.
Professor V. H. Blackman, Sc.D., F.R.S., F.L.S. (Vice-Chairman).
S. S. Boorman, Esq.
G. T. Cook, Esq.
J. S. Chivers, Esq.
L. J. Cook, Esq.
Alfred Day, Esq., J.P.
W. T. Edmonds, Esq.
Professor Dame Helen Gwynne-Vaughan, G.B.E., D.Sc., LL.D., F.L.S.
Sir Daniel Hall, K.C.B., M.A., F.R.S., D.Sc., LL.D.
P. Manwaring, Esq., J.P.
S. W. Mount, Esq. (Chairman).
Rt. Hon. Lord Northbourne, C.C.
T. Neame, Esq. (Chairman, Finance Sub-Committee).
J. M. Robertson, Esq.
Professor E. J. Salisbury, D.Sc., F.L.S., F.R.S.
J. E. Sandall, Esq.
W. J. Thomas, Esq.
Capt. R. Wellington.

Co-opted Members:

H. V. Taylor, Esq., O.B.E., D.Sc.(Lond.), A.R.C.S.
Horticultural Commissioner, Ministry of Agriculture.
W. Rogers, Esq., Court Lodge, Horton Kirby, Kent.

The Director:

R. G. Hatton, Esq., C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H.

The Representative of Staff Council:

M. H. Moore, Esq., Dip.Hort.Sci.(Reading).

STAFF

Director : RONALD G. HATTON, C.B.E., M.A.(Oxon.), D.Sc.Hort.(Lond.), V.M.H.

Assistant Director : H. WORMALD, D.Sc.(Lond.), A.R.C.S., D.I.C.

Technical Officer : N. B. BAGENAL, B.A.(Cantab.)

Assistant to Technical Officer : H. B. S. MONTGOMERY, B.A.(Dublin), Ph.D.(Lond.), D.I.C. (*Part time.*)

Pomology : R. G. HATTON,* C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H.
N. H. GRUBB, M.S.A.(Cornell).
W. S. ROGERS, M.A., Dip.Hort.(Cantab.).
J. AMOS, N.D.H.
W. A. BANE, B.Sc.Hort.(Reading).
Miss A. B. BEAKBANE, B.Sc.Hort.(Lond.), N.D.H.
Miss M. G. WEBB, B.Sc.Hort.(Reading). (*Resigned December,* 1937.)
Miss C. P. FIELD, B.Sc.Hort.(Reading).
Miss E. C. THOMPSON.
Lab. and Field Assistants : C. H. W. SLATER.
Miss E. C. M. ASHDOWN.
Miss F. M. HODGE.
Miss M. E. J. BROAD.

Plant Breeding : H. M. TYDEMAN.

Propagation : R. J. GARNER, N.D.H., Dip.Hort.Sci.(Reading).
D. H. HAMMOND.

Marketing Investigations : A. C. PAINTER.
Miss B. L. WATES, B.Sc.Hort.(Lond.). (*Resigned October,* 1937.)
Lab. Assistant : R. A. WARD.

Hops : F. H. BEARD, Hort.Dip.(Wye).

Walnuts : A. W. WITT, N.D.H. (*Consultant*).

Statistics : T. N. HOBLYN, Hort.Dip.(Wye).
Miss J. L. EDGAR, B.Sc.(Lond.). (*Resigned December,* 1937.)
S. C. PEARCE, B.Sc.(Lond.). (*Appointed January,* 1938.)
Lab. Assistant : Miss J. S. PLACKETT.

Plant Physiology : M. C. VYVYAN,* M.A.(Cantab.).
H. L. PEARSE, Ph.D.(Lond.), A.R.C.S., D.I.C., of the Imperial College of Science and Technology.
Lab. Assistant : G. F. TROWEL.

* Recognized Teacher of the University of London.

Bio-Chemistry : W. A. ROACH,* D.Sc.(Lond.), A.R.C.S., D.I.C., A.I.C.
B. G. F. LEVY, B.A.(Cantab.), Hort.Cert.(Reading). (*Resigned December,* 1937).
J. K. EATON, B.Sc.(Wales), M.Sc.Tech.(Manc.). (*Appointed October,* 1937.)
Lab. Assistants : R. CORNFORD. (*Resigned July,* 1937.)
F. R. USMAR. (*Appointed January,* 1938.)

Mycology and Bacteriology : H. WORMALD,* D.Sc.(Lond.), A.R.C.S., D.I.C.
R. V. HARRIS, B.Sc.(Lond.), A.R.C.S., D.I.C.
H. B. S. MONTGOMERY, B.A.(Dublin), Ph.D.(Lond.), D.I.C. (*Part time.*)
Lab. Assistants : Miss R. HOAR. (*Resigned November,* 1937.)
R. HUMPHREYS. (*Appointed January,* 1938.)

Entomology : A. M. MASSEE,* D.Sc.(Lond.), F.R.E.S.
R. M. GREENSLADE, B.Sc., A.R.C.S.
Lab. Assistant : F. CRONK.

Insecticides and Fungicides :
Chemistry : H. SHAW, M.Sc.Tech., Ph.D.(Manc.).
Lab. Assistant : R. N. PIERCE.
J. J. T. HUMPHREY.
Entomology : W. STEER, B.A.(Cantab.)
R. G. GAMBRILL, *Lab. and Field Assistant.*
Mycology : M. H. MOORE, Dip.Hort.Sci.(Reading).
Lab. Assistant : J. JEFFERYS.

Guide Demonstrator and Exhibitions Officer : H. C. CHAPELOW, *Meteorological Records.*

Photographer : Miss K. E. CORNFORD.

Lab. Stewards : Miss K. E. CORNFORD.
R. G. GAMBRILL.

Advisory Officers in Commercial Fruit Growing to the Kent Education Committee stationed at East Malling Research Station : W. G. KENT, N.D.H., and C. R. THOMPSON.

* Recognized Teacher of the University of London.

ADMINISTRATION.

Secretary : C. T. ROYLE.

Book-keeper : P. R. WOOD.

Director's Personal Secretary : Miss L. E. ALEXANDER.

Clerical Staff : Miss G. O. ARDAGH, Miss J. BANKS, Miss J. M. COY, Miss J. M. CRAYFORD, Miss J. D. MARTIN, Miss L. F. R. OWEN and Miss M. I. SUNNUCK.

VISITORS.

Visits may be paid to the Research Station on any weekday *by appointment* (Saturday afternoon under exceptional circumstances only).

Passenger Station : East Malling Halt (Southern Railway).

Goods Station : Aylesford (Southern Railway).

Bus Services :

FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling Church.

FROM LONDON a regular service of Maidstone and District Coaches from the London Coastal Service Limited, Victoria Coach Station, Buckingham Palace Road, S.W.1, may be of assistance to Visitors. The Coaches call at East Malling on certain inward and outward journeys.

For Visitors coming by road DITTON CORNER on the main London-Maidstone Road is the turning to the Research Station.

Telephone : Aylesford 7294 (2 lines).

Telegrams : Research, East Malling.

THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

accommodated at East Malling Research Station.

STAFF.

Director : RONALD G. HATTON, C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H.

Deputy Director : D. AKENHEAD, M.A.(Oxon.), B.Sc.Agric.(London.)

Assistants : G. ST. CLAIR FEILDEN, B.A.(Oxon.)
G. K. ARGLES, Dip.Hort.(Wye), A.I.C.T.A. (*Resigned September*, 1937.)
B. VON HEISELER, F.I.L. (*Appointed November*, 1937.)

Clerical Staff : Miss M. B. ROGERS, Miss M. M. DURLING, and Miss F. R. L. CLEGGATT.

Telephone : Aylesford 7188.

EDITORIAL

The Station's Annual Report is issued in two parts. That dealing with the general development and activities of the Station is published as a Supplementary Report which is presented by the Executive Committee to the Annual General Meeting; it is mainly for the use of our Committee and Members, and is circulated separately to our Members.

The Annual Report of research work consists of four sections as follows:

I. The Experimental Farm.

II. General Review of Research Work, with Summaries of Papers published during the Year.

III. Preliminary Research Reports and Progress Reports.

IV. Bulletins for Fruitgrowers.

In the General Programme of Research work the numbers accompanying the projects set out to correspond to those of last year. This Section includes complete lists of papers published by the Staff during 1937 together with summaries of those papers not readily available to most of our Members. Papers published in our Annual Report for 1936 are mentioned in the lists but not summarized since they are either in the hands of our Members, or can be purchased from the Station.

The general editorship of this Report has been undertaken by Dr. Wormald, but heads of Sections are responsible for the sectional reports.

R. G. Hatton.

Section I

THE EXPERIMENTAL FARM

Contributed by J. AMOS, F. H. BEARD, R. J. GARNER, M. H. MOORE and A. C. PAINTER, with an introduction by R. G. HATTON

INTRODUCTION.

This section of our Annual Report was introduced in 1930. It appears to have served the purpose of keeping many of our grower Members interested in the developments on the farm, and of helping them to visualize something of what it means to run a fruit farm experimentally. Incidentally, many of them have stated that they have found some of the experiences herein described valuable even though they deal with somewhat exceptional conditions.

The land farmed by the Institute for experimental purposes is now approximately 160 acres, including Kiln Field (18 acres) and Deadman (12 acres)—owned by the Trustees of our Development Fund—and Merryweather, a field of 10 acres, adjoining our nursery ground, and recently obtained by them on lease.

Approximately 100 acres—Great East Field (22 acres), Egham Field (40 acres), Church Field (20 acres), together with Kiln Field—lie to the west of the Ditton-Kiln Barn parish road, and, apart from the considerable area now occupied by buildings, approaches and numerous headlands (totalling some fifteen acres on the whole farm) are fully planted up with apple, pear, plum and cherry orchards now reaching maturity. Some 9 acres are given over to the hop garden.

Although these orchards are now capable of producing a considerable crop of fruit, it must be remembered that they contain many " uncommercial " varieties and rootstocks, which it has been necessary to plant for experimental purposes, and that these orchards are cut up into many different pruning, manuring, cultural and spraying treatments and untreated plots so that they cannot all be expected to yield uniformly satisfactory results. In fact, very few of the treatments represent our ideal, and our Members have now learned not to expect to see " everything as it should be " on a research farm. It is rather the function of educational authorities to give such demonstrations of the latest approved findings which are to be deduced from the investigations at the Station.

In addition to all this, it should be remembered that the Station must keep a considerable and regular labour staff, not only to get the experimental treatments carried out at the crucial moment, but also to cope with the ever-increasing crops which have to be harvested by such a long process. Although, in many instances, we have learned to rely on sampling methods to obtain our data, it will be appreciated that a few samples off a twenty-year-old tree amount to far more than the whole crop off a ten-year-old one. For instance, the problem of measuring the productivity of standard cherry trees with any degree of accuracy is a comparatively new one. It is the same with all our other records of girth, number and weight of prunings, blossom counts, fruit drops and the final harvest. Too often we have regretted the omission of observations upon one or other of these phases of the tree's response. We now have always to be equipped with the necessary labour for carrying them out. There should be at least another twenty years over which valuable experimental data should be accumulated. What is the

profitable life of an apple or cherry orchard, for instance, properly tended throughout ? And what are the omissions leading to deterioration ?

The remaining 60 acres to the east of the parish road has so far not been developed for permanent orchards in the main, though Newgates Shaw (3 acres) has been planted up with some sixty varieties of walnut and a collection of cobs and filberts. Newgates Field (25 acres) is owned by the Station, and has been used for small fruit experiments and nursery work, but the development of adjacent quarrying activities has now rendered much of this land unsuitable for the former at least. Deadman (12 acres), purchased by our Trustees, has some 4 acres occupied with plum die-back studies, but the rest is used for nursery work. Upper Grub (10 acres), Newgates Shaw (3 acres) and Merryweather (10 acres) are all held on lease. Apart from a small isolation garden of clonal Golding varieties of hops, Upper Grub has been occupied with nursery work and with intensive nursery trials of new rootstocks which are yielding very valuable results, but are of course quite unprofitable. Indeed the amount of excavation work involved during the past winter has been abnormally costly. Merryweather which has recently been acquired, will also be used mainly for nursery operations though some 4 acres were already planted up with Cox's Orange Pippin and Worcester Pearmain on No. IX rootstock. These trees are being recorded so that they will eventually become available for investigational requirements. The experiments in large scale strawberry runner raising which were the result of an insistant demand for plants " rogued " for " Yellow-edge " disease, following the good performance of our clonal strain, have proved costly in ground and labour. When such operations are conducted with the experimental object in the forefront, the economic aspect is apt to become secondary, at least in the early stages of the project. We have the consolation of having been instrumental in establishing some excellent daughter nurseries in well isolated locations.

In continuing, then, to publish this annual account of the activities, crops borne and prices realized on the experimental farm, we would ask our readers once again to remember that we are not attempting to show them how to run a commercial business but merely to interest them in our experimental experiences and to try to give them an economic aspect. From these facts then, there is something to be learned each year, if all the necessary qualifications and disabilities or " experimental exigencies " are borne in mind. We have recounted these so fully in former years that it should be unnecessary to repeat them on every occasion. (R.G.H.)

FARM REPORT

Cultural.

Owing to the very wet conditions that prevailed throughout the first three months of the year all work on the farm was carried out with great difficulty and in many cases considerable extra expense was incurred. During this period rain fell on sixty-three days and the amount recorded for each month was more than double the average for these months previously recorded at this Station.

Conditions were warm and showery during the greater part of April and generally suited the blossoming of most fruit trees. However, the cold spell with moist conditions during the blossoming of sweet cherries did much damage, and many varieties set a poor crop.

During May also the rainfall was double the average for that month, but ample sunshine and average temperatures were favourable to all fruit crops. The amount of blossom on the various fruit trees was somewhat variable, due no doubt to very heavy

crops produced during 1936. Plums in most cases carried sufficient blossom for an average crop, as was the case with Victoria, but Czar, Purple Egg, Yellow Egg and Giant Prune eventually had to be thinned. Pears, with the exception of Conference, were definitely in their off year. Most varieties of apples blossomed lightly, particularly Bramley's Seedlings and Lane's Prince Albert, but Worcester Pearmain blossomed profusely and set heavy crops.

The general moist conditions were ideal for the growth of both soft and bush fruits. Towards the end of June and also during July, dull cold weather prevailed and this had the effect of causing much rotting of the fruit of strawberries. August was a month of sunny weather with high temperatures, which probably helped in giving finish to such apples as Worcester Pearmain and Cox's Orange Pippin, both of which were outstanding for quality and finish in 1937. The weather during the remaining months of the year was not remarkable in any way and did not interrupt the carrying out of normal routine farm operations.

Fresh Plantings, Grubbings, etc.

Great East Field. The only fresh planting that has been done on this field has been one half acre with varieties of raspberries for the purpose of raising mosaic-free canes. On the plot of twenty-year-old double-worked apples certain rows of Bramley's Seedling, Lane's Prince Albert, and Worcester Pearmain have had to be thinned.

Egham Field and Church Field. Except for very small areas, both these fields are now fully planted up. The plot (30), at one time planned to demonstrate the most suitable stocks for " permanent " and " filler " trees, became too crowded and certain varieties such as Belle de Boskoop, Blenheim Orange and Annie Elizabeth, mostly on strong stocks have been removed. The remaining rows of filler trees on No IX on this plot are, for a time, being retained for various intensive experiments. The very dwarfed Huesgen's Golden Reinette have been used for the extension of " inarching " investigations. The alleys, eighteen feet in width, between these rows of trees are to be sown with various grass and clover mixtures in order to find out the best " leys " for our conditions and their relative value for supplying humus to the soil.

On the variety collection plot sixteen varieties of apple which were not of economic importance have been frameworked to Cox's Orange Pippin, and these will be watched to see what effect the different intermediates have upon the Cox scion.

The cherry variety plot on the Egham Field, planted 30 by 30 feet and interplanted in 1925 with standard Czar, Purple Egg and Utility plums at 15 feet, has now become too crowded. Instead of grubbing the alternate plums in each row to give room to the cherries, some of the Czars and Purple Egg will be frameworked in 1938 with choice Gage and other varieties of plums in order to obtain information as to which varieties are compatible, especially with Czar. This method should, if successful, enable such plums as Czar and Purple Egg to be changed over to more profitable varieties and so relieve the market of two plums which are often difficult to dispose of.

One acre of Royal Sovereign strawberry plants which produced runners during the past season, has been ploughed in.

Newgates Field. The five acres planted with clonal Royal Sovereign strawberries in the autumn of 1936 was drastically thinned and used for runner raising during the past season to meet the request of our members for " Yellow-edge " rogued plants. They will be retained for this purpose during 1938, as there is a definite demand for runners off two-year parents.

Two acres of six-year-old Lloyd George raspberries have been grubbed, the land ploughed, subsoiled and prepared for the experimental nursery material. A portion of this two acres will be used for successive demonstration nurseries upon which can be studied growth and compatibility of stock and scion in relation to meteorological records.

Walnut trees in Newgates Shaw made little progress planted in clearings in the copse. By deeply digging a wide circle around each tree and giving to each a good dressing of dung the trees have now made a good start into vigorous growth. Some of the older trees have already borne some nuts.

Upper Grub. The half acre of new seedling black currants has been grubbed, cuttings of the best selections being retained for further trial. The land has been planted with Royal Sovereign strawberries.

The intensive nursery trial of new plum rootstocks, worked with Czar and Victoria, has remained in situ for five years. The trees have now been thinned in such a way so as to leave in position sets of trees upon all rootstocks for a further period of years. From the trees removed, comparable sets of the most promising new stocks have been planted out on Deadman Field at fifteen feet apart, for a more extensive trial.

The standard trees of the apple stem builder trial, after remaining in the nursery for six years, have been lifted and final detailed observations recorded of branch, stem and root weights. Some of the trees in the series of " stock on stock " investigations, both pruned and unpruned batches, have been lifted and the effects on branches and roots recorded. Two new nursery trials have been planted—the one, a series of new apple stocks worked with Cox's Orange Pippin, and the other consisting of pears, Dr. Jules Guyot, Conference and Marie Louise worked upon new quince rootstock selections.

Kiln Field. It has been found necessary to do further thinning of apples on this field. Six acres of twenty-two-year-old Bramley's Seedling have had alternate rows removed ; this now leaves a square plant 24 by 24 feet. One acre of twenty-two-year-old half-standard Cox's Orange Pippin interplanted with King Edward has had the latter variety taken out. The block of Lane's Prince Albert interplanted with Lord Derby has been frameworked with Cox's Orange Pippin and another block of Gladstone is to be worked with Worcester Pearmain in 1938. The thinning of trees where necessary, combined with the reworking of worthless varieties with sorts known to stand up to modern sprays should make this field a more economic unit.

Deadman Field. The six acres of clonal Royal Sovereign strawberries from which runners were taken in 1936-37 were, on account of their vigour, fruited during the summer and were subsequently allowed to produce a crop of runners. No apparent ill effects have followed this treatment for the present plants are still remarkably strong and free from " Yellow-edge ", and produced a crop of healthy runners. The remaining six acres of open land was cropped with barley and, immediately after the crop was harvested the ground was heavily dunged and ploughed in readiness for strawberries. In October, runners of our clonal Royal Sovereign, raised in an isolated daughter nursery, were planted for cropping and other trials, but the at present inadequate supply of " rogued " Yellow-Edge free runners necessitates this area being used for further nursery purposes. In order that out runner raising beds shall as far as possible be free from risk of infection from aphis, all adjacent fruiting plants, some ten acres in all, are being ploughed in.

Merryweather. This field of ten acres, adjoining the Deadman Field, has been obtained on a lease by our Trustees. During 1935-36 the previous owner planted 4 acres with Cox's Orange Pippin and Worcester Pearmain upon No. IX rootstock. This area together with a further 5 acres, was planted with clonal Royal Sovereign runners raised

and supplied by the Station. This procedure was adopted in order to avoid runners from an unknown source being planted and to forestall the possible risk of infection to our adjacent fields. The whole area was used for runner production in 1936-37 by the former owner, in collaboration with the Station. The plants were fruited during 1937. They have now all been ploughed in and four acres between the trees has been planted with bedded rootstocks. The other 5 acres will be replanted in the spring to Royal Sovereign strawberries. (J.A.)

PROPAGATION.

Stoolbeds.—(Area under cultivation about 10 acres.) The production of clonal layered rootstocks forms one of the chief activities of the Propagation Section and whilst this contributes a considerable sum to the income of the experimental farm, at the same time, a large amount of labour is thus expended, particularly at certain times of the year. During the period October-March the unearthing, cutting-off, trimming, grading, and bedding involve a great deal of hand labour. For the period under review this was made heavier than usual by the prolonged wet weather, and consequently costs were abnormally high.

About half a million rootstocks were raised and distributed, chiefly to the nursery trade, but also in numerous experimental consignments to our grower Members. In addition many collections of rootstocks were sent to research and educational institutions at home and overseas.

Following upon the results obtained from rootstock trials it has been possible to reduce the number of rootstocks raised on a large scale to those of most use to the grower.

These at the request of the fruit tree nurserymen, are still raised in bulk, and sold at prices which compare favourably with those of the trade.

General nurseries.—(Area under cultivation about 12 acres). The propagation of material other than the stoolbeds and strawberry runner beds is carried out on comparatively small pieces of land temporarily vacated or waiting planting with permanent crops.

Thus these areas are scattered throughout the farm and are, for this reason, rather more costly to cultivate than if they were together. However, by making use of odd pieces of land in this way, it is possible to continue propagation projects without using land required for large scale trials.

Much of the work of general propagation is not directly remunerative as almost all budded and grafted trees are requisitioned for experimental plantings at the Station and elsewhere. Moreover the preparation of this material often involves the employment of differential treatment for particular purposes and thus a larger amount of labour and supervision is required than in commercial nurseries.

Other than the black currant Wellington XXX, and certain clonal selections of blackberry, bush fruits were not propagated extensively during the year but, at the same time very many varieties of currants, gooseberries and raspberries were raised in small quantities.

Strawberry Runners.—(Area under cultivation 14 acres). Seven hundred thousand runners were raised and distributed during the year leaving one hundred thousand for lifting in the spring of 1938. All these plants, except for seventy-three thousand Tardive de Leopold, were the progeny of our selected clone of Royal Sovereign, grown under the isolated block system, and had been carefully "rogued" for virus diseases throughout their life. This large-scale propagation of runners was new to the Station

and grew out of the demand for "Yellow-edge" rogued plants. Lack of previous experience, coupled with the adverse weather conditions at the time of lifting, and the abnormal weed growth accompanying the wet summer of 1936, made the work more difficult than it otherwise would have been. Runners are required during a short period in spring and autumn and it is particularly necessary that the work should proceed rapidly. In order to ensure this it is essential to organize the work to the best advantage. Our difficulties in this direction were very great but after receiving much help from one of our members who has had a long experience of runner raising, we were able to effect a decided improvement.

It has so far proved surprisingly difficult to obtain an accurate estimation of the runners available for allotment to members. The estimates have always been too optimistic. The patience of those who have been disappointed and the helpful advice given in this matter have been much appreciated, and it is hoped that in future a truer picture of the total production may be available. (R.J.G.)

MARKETING.

In contrast to the last two years when soft fruit crops were largely ruined by frost, there were good yields of strawberries, raspberries, currants, loganberries and blackberries. Acid cherries too did well. Plums on the whole were a good crop, but apples and pears which had produced bumper crops in 1936, were, with few exceptions, light. This was reflected in the amount of fruit available for gas storing, there being only sufficient Bramleys, Lanes and Edward VII combined to partially fill one of the three chambers.

Gross receipts from the 1937 crop apart from the apples now in gas store have amounted to some £4,500 made up as below. In addition a sum of £1,475 was received for gas-stored apples of the 1936 crop marketed between March and June.

	£	Average Price. s. d.	
Strawberries	865	6¾	a lb.
Raspberries	380	4¼	,,
Red Currants	63	4¾	,,
Black Currants	651	4½	,,
Loganberries	42	4½	,,
Blackberries	40	3¾	,,
Gooseberries and peaches	21	—	,,
Cherries, Acid	322	4¼	,,
Cherries, Sweet	111	5¾	,,
Plums	721	5 7	a half sieve.
Pears	89	8 6	a bushel.
Apples (1937 crop)	1,200	7 0	,,
Apples (1936 crop)	1,475	5 7	,,

Unless otherwise stated prices are gross and those obtained for the main crop, odd consignments at the beginning and end of the season not being taken into account.

INDIVIDUAL CROPS.

Strawberries.—(Area under cultivation—2 acres of experimental plots in Egham Field and Great East. Also 8 acres in Merryweather interplanted between apples and 6 acres in Deadman interplanted between plums; both these last two had been used for runner production in 1936. All plantings consisted of two-year-old clonal Royal Sovereigns.)

The experimental plots, which were deblossomed in 1936 and were thus fruiting for the first time, cropped heavily, yielding from two to four-and-a-half tons per acre according to their experimental treatment, and averaging about two-and-a-half tons of marketable fruit to the acre. Had it not been for a severe attack of Botrytis (mould) brought on by damp weather, the yield would have been over five tons per acre in some cases. The quality was excellent; sixty-seven per cent. of the crop reached National Mark Standard and the gross return worked out at £66 a ton.

The other two plantations are interesting as giving an indication as to what may be expected from plants that have been utilized for runner production in their first year and then allowed to crop.

The 8 acres of old runner bed in Merryweather which were autumn planted in blocks at 3 foot by 1 foot 6 inches with 3 feet between were somewhat weakly after being used for runners and the fruit was rather small. For this reason and owing to the fact that on the night before picking torrential rain fell causing considerable splashing of the fruit with dirt even where the straw was thickest thus necessitating the washing of the greater part of the first two pickings, no attempt was made at grading other than to keep out damaged, gritty, and very small fruit. Some 5 tons 17 cwt. were picked from this plot, giving an approximate yield of 15 cwt. to the acre at the wide planting distance already mentioned, and a gross return of £59 a ton.

Three acres in Deadman similar to the above, but spring planted under seven-year-old plum trees gave an approximate yield of 12 cwt. to the acre, the price obtained for the fruit being also £59 a ton.

The remaining 3 acres in Deadman had been planted on a different method, viz. at 3 foot square. These plants, in spite of having been used for runners, were extremely large and produced excellent quality fruit, as much as 63 per cent. being of National Mark Standard. The yield averaged 14 cwt. to the acre and gross return £64 a ton. It must be remembered that there were at most 4,000 plants per acre.

Botrytis also caused considerable wastage on both Merryweather and Deadman, but was not so extensive as on the experimental plots where the foliage was more luxuriant and the plants closer.

The weather was damp, cool and dull throughout the period of picking. The fruit in consequence ripened slowly and no harm was done by allowing two or even three days on occasions to elapse between pickings.

To facilitate recording on the experimental plots, extra selected and selected National Mark fruit was picked together and marketed in 3 lb. Climax baskets. The same method was adopted for the 3 foot plant on Deadman. In view, however, of the apparently increasing demand for a smaller package, possibly a 2 lb. chip would be better for fruit of this quality. Fruit under National Mark size was marketed in shallow 6 lb. chip baskets as " Smalls ", and ungraded fruit in 3 lb. chips. Tubs were used for the jam fruit.

Prices were as follows:

Mixed Extra selected and Selected National Mark fruit from 6d. to 10d. a lb., averaging 8d.
Smalls from $4\frac{1}{4}$d. to 6d. a lb., averaging 5d.
Ungraded from 4d. to 8d. a lb., averaging $6\frac{3}{4}$d.
Jam fruit averaged 3·4d. per lb.

Raspberries.—(Area under cultivation about 4 acres of four-year-old Lloyd George and 1 acre of three-year-old new seedlings in Newgates Field. Also small patches of new seedlings and odd varieties in Egham Field.)

The 4 acres of Lloyd George yielded just over 9 tons, or at the rate of 2¼ tons to the acre. A further 2 tons was picked from the remaining plots. Of this some 31 cwt. were marketed in 3 lb. chips at an average price of 6d. a lb. The remainder was sold in tubs for jam the average price being £29 15s. a ton or 3·2d. per lb.

The new seedlings raised by N. H. Grubb and now being tried out on Newgates showed considerable promise both as regards quality and weight of fruit.

Red Currants.—(Area under cultivation. A variety and cropping trial comprising ¾ acre of six-year-old bushes interplanted between pears in Egham Field.)

The total quantity picked was 28½ cwt. or at the rate of 38 cwt. to the acre. The quality of fruit was mainly good and fetched from 3½d. to 6d. a lb., the average price being 4¾d. As usual it was marketed in 6 lb. chips.

For those requiring a late variety Wilson's Longbunch would seem to give considerable promise. The fruit is an attractive light red colour and in our experience always commands a good price, this year ranging from 5d. to 6d. a lb.

Black Currants.—(Area under cultivation—2 acres of five-year-old Baldwin and Wellington Triple X and 2 acres of four-year-old mixed varieties in Newgates Field, 4 acres of four-year-old Wellington Triple X interplanted with plums and cherries in Church Field and ½ acre of new seedling crosses.)

The black currant crop was good, the 4 acres of experimental plots and odd varieties in Newgates Field yielding 7 tons 8 cwt. and the 4 acres of Triple X in Church Field 7 tons 2 cwt. Another 17 cwt. was picked from the ½ acre of seedling crosses.

Prices ranged from 4d. to 7d. a lb. and averaged 4·6d. A somewhat higher average price would have been attained had not some of the fruit on Newgates Field been rather badly soiled by quarry dust.

As last year the crop was marketed in 4 lb. chips.

Loganberries and Blackberries.—(Area under cultivation—approximately ¾ acre in Church Field and Great East.)

The total crop of loganberries amounted to a little over 1 ton, and brought in £42. Selected (National Mark) fruit sold steadily at between 5d. and 6d. a lb. and lower grade fruit from 3d. to 6d. The average price throughout was 4·4d.

The blackberry crop came to 21 cwt., and sold at an average of 3¾d. a lb. Prices fluctuated considerably, ranging from 2d. to 7d. a lb.

Both loganberries and blackberries were marketed in 3 lb. chips.

Cherries.—(Area under cultivation—⅔ acre of fourteen- to sixteen-year-old Morellos, planted at 12 by 12 ft., ½ acre of eleven-year-old Morellos, ⅔ acre of ten-year-old Kentish Red and ⅓ acre of Carnation and young Morellos all at 15 by 15 ft., in Egham Field. In addition ¼ acre of nine- and ten-year-old Morellos in Newgates Field held at the disposal of the Pathology Section for spraying trials. A miscellaneous variety collection of sweet cherries in Egham Field, and a stock trial comprising 6 acres of ten-year-old Early Rivers, Schrecken and Turk interplanted between plums and black currants at 30 ft. apart in Church Field.)

The Morellos gave their first crop for three years after being cut by frost for two years in succession.

The fourteen- to sixteen-year-old trees, half of which were dehorned in 1932, and the other half in 1936, were somewhat patchy, but on the whole cropped well averaging some 3½ tons to the acre.

The eleven-year-old trees at 15 by 15 ft. were more uniform and carried a heavy crop for the size of the trees; their yield was also 3½ tons to the acre. The quality of

the fruit from this plot was extremely good, 80 per cent. reaching National Mark Standard.

The Morellos on the Pathology plot, too, cropped well, but the fruit was smaller than elsewhere.

The fruit was graded into two grades—Selected (National Mark) and Grade 1. The feeder of the plum grader which consists of a 10 foot moving canvas belt was used for the purpose, and worked admirably, the method employed being as follows: The feeder is detached from the grader and run by an electric motor, the cherries being fed on to one end. The sorters standing on either side of the moving belt removed the damaged and small fruit and also the Grade 1 as the fruit passed in front of them, leaving the Selected, which formed the larger proportion, to go on and fall into chips at the other end of the belt.

A grader of this description needs at least five persons to run it but it is usually more economic to employ about twelve, either one or two feeding, eight sorting (four each side) one attending to the chips at the other end of the grader, and one or two weighing and lidding down. It is best, without being too rigid, to give definite duties to the sorters in some such way as follows: the first pair (one either side) to be primarily responsible for removing the cull fruit, the next two pairs one of the grades destined for market, and the last pair and the packer at the end any of these two categories that may have been missed. The grade allowed to remain on the belt should of course be the grade with the most fruit in it.

The total crop amounted to a little over 4½ tons and realized £195 or a gross return of 4·6d. per lb. Prices obtained for the different grades were:

Selected (National Mark) fruit marketed in 6 lb. chips, and representing 70 per cent. of the crop, an average of 5d. a lb.

Grade 1 in 12 lb. chips, and representing 28 per cent. of the crop, an average of 3½d. a lb.

As usual the trees were picked over two and in some cases three times, the fruit being allowed to become a dark red colour, though not overripe. Scissors are used for gathering the crop to obviate damage to the buds and to prevent stripping of the bark.

The Kentish Red, which like the Morellos had had no fruit for two years, also cropped heavily giving the high yield of 3 tons 17 cwt., or 5 tons 15 cwt. to the acre.

The fruit which was marketed in 12 lb. chips was not graded other than to exclude blemished and small fruit. Gross receipts amounted to £123 or an average of 3·3d. per lb.

The Carnation produced only a negligible quantity of fruit in spite of the trees being ten years old. This variety has yet to set its first crop.

Scissors are used for gathering the fruit of Kentish Red and Carnation in the same way as for Morellos.

Sweet cherries were a light crop and only yielded some 2 tons. Prices for what fruit there was, however, were good, black cherries fetching from 5s. to 8s. 6d. a 12 lb. chip, and others from 3s. to 7s. The gross return amounted to £111.

Pears.—(Area under cultivation 6 acres in Egham and ½ acre in Church Field, five of which consist of a number of different varieties from eleven to eighteen years of age. The other acre, consisting of seven-year-old trees is just coming into bearing.)

Pears were an extremely light crop, the quantity of marketable fruit amounting only to some 210 bushels.

Low grade pears such as Reine de Poires and Hessle fetched from 3s. 6d. to 7s. a bushel, while Conference and the better sorts made up to 6s. 6d. a half-sieve.

Gross receipts amounted to £89 or an average of 8s. 6d. a bushel.

Plums.—(Area under cultivation 3 acres of fifteen-year-old and 2 acres of twelve-year-old trees interplanted with cherries in Egham Field, $2\frac{1}{2}$ acres nine-year-old trees in Church Field, interplanted with cherries and black currants, $\frac{1}{2}$ acre of Czars and Myrobolans planted for windscreen purposes in Egham and Newgates Field.)

The quantity of plums dealt with was only half what it was in 1936, partly due to the fact that $3\frac{1}{2}$ acres of twenty-year-old trees in Kiln Field had been grubbed the previous winter, and partly because the crops of many varieties, including Victoria, were light after the heavy yield of the previous year.

For the second year in succession Czars, Pershore Egg, Purple Egg, and Giant Prune set heavy crops. The fruit of all these was thinned to $1\frac{1}{2}$ inches apart between the stalks, thinning being carried out between 7th and 21st June. Other varieties to crop well were Early Rivers, Warwickshire Drooper, President, and Cluster Damson. Varieties that were noticeably light compared with 1936 were Victoria and Greengage. Myrobolan for the third year in succession failed to set a crop.

Prices were generally higher than in 1936, those for some of the main varieties marketed straight from the tree being as follows:

	National Mark. Equivalent per half-sieve of 24 lb.	Lower Grade. Equivalent per half-sieve of 24 lb.
	s. d. to s. d.	s. d. to s. d.
Early Rivers	7 0 to 10 0	4 6 to 8 0
Czars	3 0 ,, 7 0	1 6 ,, 6 0
Pershore Egg	1 9 ,, 4 0	1 3 ,, 2 6
Purple Egg	3 0 ,, 4 0	1 6 ,, 2 6
Victoria	4 0 ,, 10 0	2 6 ,, 7 0
Giant Prune	3 0 ,, 7 0	2 6 ,, 5 0
Greengage	10 0 ,, 14 0	7 0 ,, 10 0
Warwickshire Drooper ..	5 0 ,, 12 0	3 6 ,, 6 0
President	7 0 ,, 14 0	4 0 ,, 7 0

A quantity of Giant Prune, Warwickshire Drooper and President and the greater part of the Damson crop were held over for a time in cold store. Some price comparisons, etc. will be found under "Storage Notes", on page 26.

Once again it will be noticed that Warwickshire Drooper, which also cropped well, commanded a good price in the market.

The total crop amounted to approximately 2,550 half-sieves and averaged 5s. 7d. gross per half-sieve.

Apples.—(Area under cultivation 23 acres in Great East, Egham, and Church Fields, consisting of many different varieties from seven to twenty-four years of age. Also 14 acres of approximately twenty-one-year planted trees in Kiln Field. Five acres of three-year-old trees in Merryweather have not yet started to bear.)

1936 *Crop.*—Some 5,300 bushels of the 1936 crop which had been gas stored were marketed between 20th March and 26th May, except for a small experimental lot of some 170 bushels which were sent to market between 12th and 23rd June.

Fancy Lanes, marketed between 20th March and 1st April, made 3s. 6d. to 5s. a bushel, and Edward VII, between 13th and 29th April, 4s. 6d. to 7s. 6d.

Fancy Bramley's, marketed in early April, were making from 4s. 6d. to 7s. a bushel, the price slowly rising to between 7s. and 10s. at the end of May. The small quantity of fruit marketed in June made from 7s. 6d. to 11s. a bushel.

Domestic standard fruit fetched on an average from 6d. to 1s. a bushel less than Fancy, and Second Quality from 1s. to 2s. less. (See also " Storage Notes " on page 24.)

1937 *Crop*.—The total apple crop amounted to approximately 5,000 bushels of marketable fruit against 14,500 in 1936. Apart from Worcester, Lord Derby, Allington, and Beauty of Bath, crops were mainly light, Bramley and Lane's Prince Albert, as a rule our main standby, failing to set any quantity of fruit in relation to their acreage. The principal yields were :

Bramley's Seedling	1,320 bushels.
Worcester Pearmain	1,300 ,,
Lord Derby	540 ,,
Lane's Prince Albert	450 ,,

Except in Beauty of Bath, Lord Derby and Allington little thinning was necessary. Wherever possible, Lord Derbys were thinned to 6 inches apart, but owing to experimental reasons thinning in the main consisted of reducing the fruit to singles. Other varieties on which some thinning was done were Worcester, Miller's Seedling and Duchess Favourite.

Almost the entire crop of Bramley's, Lane's Prince Albert and Edward VII (approximately 1,600 bushels) was placed in gas store in October for marketing in March and April.

Of the fruit sold, quality was good in the case of Worcesters, 69 per cent. of the fruit reaching National Mark Standard. In many of the later varieties, however, there was a good deal of cork, bitter pit and lenticel spot—troubles often associated with light crops. Allington and Newton Wonder were particularly affected.

Prices were good, very little fruit, however poor, making less than 4s. a bushel. Some examples are :

Beauty of Bath.—Fancy Grade (National Mark) from 3s. 6d. to 6s. a half-box.

Worcester Pearmain.—Extra Fancy (National Mark) from 8s. to 12s. a box, Fancy from 6s. to 11s., and lower grades at the rate of 3s. to 7s. a bushel.

Cox's Orange Pippin.—Extra Fancy in trays from 5s. 6d. to 7s. and in half-boxes from 11s. to 14s. Fancy in trays from 4s. 6d. to 6s. and in half-boxes from 9s. to 13s. Lower grades fetched from 4s. 6d. to 10s. a half-sieve according to size and quality. Cox did better in trays than for one or two years past, and it seems that this method of marketing may be more profitable in years when the crop is short.

Grenadier (over 2½ in.).—Fancy from 5s. 6d. to 9s. a bushel. Others from 4s. 6d. to 7s.

Lord Derby (over 2½ in.).—Fancy from 3s. to 7s. a bushel. Others from 2s. 6d. to 5s.

Newton Wonder (over 2½ in.).—Fancy from 8s. 6d. to 11s. Others from 5s. to 10s. 6d.

Bramley's (over 2½ in.).—A few fancy Bramley's that had not been gas stored made from 10s. to 13s. Others from 4s. to 9s.

The average prices obtained for a number of varieties is given in Table V. Although the quantities marketed are in most cases very small, the figures give a good idea of the trend of prices.

Apart from the fruit put into gas store gross returns amounted to some £1,200 or just over 7s. a bushel compared with 3s. 9d. in 1936.

1,570 bushels have so far been sold under the National Mark, or approximately 60 per cent. of the crop of those varieties eligible for marketing under the Scheme.

(A.C.P. and B.L.W.)

STORAGE NOTES.

General.—During the first five months of the year the gas stores were fully utilized for the 1936 apple crop. These had been placed in store during September and October and were marketed between March and June.

In September one of the chambers was used for storing a small quantity of plums and damsons.

The 1937 apple crop was very light and there was only sufficient fruit to partially fill one of the chambers ; of the remaining chambers one was used as a cold store and the other as a cool store for apples.

Some notes regarding the above are given below :

Gas Storage—Apples.

Experience with the 1936 crop was very similar to that with the crop of 1934 when apples were last gas stored and confirmed the impressions then gained (see Report for 1936, p. 213). In all some 5,000 bushels of Bramley's, 300 bushels of Lane's Prince Albert, and 300 bushels of Edward VII were stored. Loading started on 7th October and finished on 3rd November.

It was originally intended to store Bramley's and Edward VII only, but owing principally to the large quantity of windfalls there was not sufficient picked fruit to fill the last chamber completely, and a quantity of Bramley's and Edward VII windfalls and rejects (i.e. fruit that had originally been rejected for storing as of doubtful keeping quality) were utilized. It is only fair to point out that this fruit, besides being of doubtful quality had been off the trees some time, as it had not originally been intended to store it. Even so, the wastage figures indicate sufficiently clearly how important it is for fruit to be got into store speedily and in the right condition, and that if it is decided to store fruit of this quality a good deal of discrimination must be used. In this connection it is of interest to note that both these classes of Edward VII, which were both in better condition and had been got into store very much more quickly than the Bramley's, had a much lower (wastage) figure.

As records had to be taken on all the fruit it was not possible to get it into store as quickly as desirable. As far as the picked fruit was concerned from two to eight days elapsed between picking and storing. The interval between starting and finishing the loading of a chamber varied from eight to twelve days.

There was little or no scald amongst the Bramley's and Lane's, but, as in 1934, there was an appreciable amount amongst the Edward VII (see also next paragraph).

Fruit Packed Ready for Market.—The opportunity was again taken to compare fruit packed ready for market in standard boxes with that stored in trays in the usual way, Bramley's and Edward VII being used. With the Bramley's wastage was slightly higher in all cases where packed in standard bozes ; slight scald was also in evidence here and there.

In the case of the Edward VII there was little difference in wastage, but there was very much more scald in the boxed fruit, the amount varying from 12 per cent. for small fruit up to 38 per cent. for the larger sizes compared with 2 per cent. and 11 per cent. for the fruit in trays.

Grading of Fruit after Storing.—Bramley's which had been put over the Cutler grader before storing were compared with similar fruit put over after storage. From the market point of view there was no difference between the two lots thus confirming the opinion previously expressed that provided the fruit has been properly stored, it can be put over the grader after storing without greater damage ensuing than if put over beforehand.

TABLE I.

WASTAGE IN GAS STORED APPLES, 1936 CROP.

Variety and Grade.	Approximate quantity. Bushels.	Period of marketing.	Approximate wastage. Percentage.
Bramley			
Fancy	2,600	23 March-25 May	1·3
Domestic	850		2·4
Second Quality ..	550		4·5
Rejects	450	2-19 April.	12·5
Drops	550	20 March-7 April.	16·5
Edward VII			
Fancy	125	16-19 April.	1·5
Domestic	25		2·7
Second Quality ..	15		4·2
Rejects	20	12-20 April.	5·4
Drops	140		5·2
Lanes			
Fancy	270	15-31 March.	3·2

Cold Storage—Apples.

A gas chamber was used to cold store a quantity of Cox's Orange, Newtons, Allingtons, Laxton's Superb, and Blenheims, and other odd varieties, the temperature being maintained round about 37° F.

A certain amount of shrivelling took place amongst the Allingtons, Cox, and Laxtons, more especially in the Allingtons. For varieties tending to shrivel, this is thought to be inevitable where a store is not full and the air has to be circulated to maintain the correct temperature. This shrivelling was noticed to be less marked in the middle of the stacks which suggests that a possible way of lessening it, under similar circumstances, is to surround such fruit with varieties not liable to shrivel, e.g. Allington might be surrounded with trays of small Bramley's. In any case it would seem wise to store the better quality fruit in the centre of the stacks and not on the top or outsides.

Cold Storage—Plums.

Plums and damsons were cold stored during September and early October. Several varieties such as Warwickshire Drooper, President, and some of the Damsons could have been stored longer if desired had it not been that the stores were required for the loading of Bramley's. The temperature of the store was maintained throughout at 34° to 35° F.

Giant Prune.—Some 31 cwt. from two different plots were stored for periods varying from 16 to 20 days.

There appeared to be a considerable difference in the keeping qualities of the fruit from the two plots. From one where 5 cwt. was involved, the wastage was as high

as 17 per cent. and in many the flesh was beginning to turn brown round the stone. In the 26 cwt., from the other plot the wastage was only a little over 6 per cent. and there was little internal browning. This discoloration is a disorder to be carefully considered for until an advanced stage is reached the fruit is usually quite sound to outward appearance. Certain varieties, such as Giant Prune, Pond's Seedling, and Monarch appear to be very susceptible to this form of damage.

Warwickshire Drooper.—2¼ cwt. were stored for a period of 17 days. When brought out the fruit was in excellent condition, wastage being only 2·5 per cent.

President.—Approximately a ton of this fruit was stored over a period of 16 to 18 days. As with Warwickshire Drooper it was in extremely good condition when brought out, the wastage here too amounting only to 2·5 per cent.

Damsons.—Several varieties were stored, the principal being :

Cluster Damson. 1 ton for periods varying from 21 to 34 days. Average wastage 5·3 per cent.

Bradley's King. 5 cwt. from 24 to 32 days. Average wastage 4·8 per cent.

Langley Bullace. 3¼ cwt. for 29 days. Wastage 5·4 per cent.

Much of the wastage amongst damsons was accounted for by shrivelling, which was most noticeable on the top trays.

Special observations were made in the case of Giant Prune and President to ascertain the relative wastage amongst plums with stalks and without stalks. This was found to be very much higher amongst plums without stalks especially for Giant Prune. This is in accordance with the warning given by the Food Investigation Board.*

The prices obtained for cold stored fruit compared with those marketed direct from the tree are given in Table II.

TABLE II.

COLD STORED PLUMS, 1937.

		Average price per 12 lb. chip.	
		Fruit marketed direct from tree.	Cold stored fruit.
		s. d.	s. d.
Giant Prune	Sel. (Large) ..	2 5	4 10
	Sel. ..	2 1	4 2
	G.1. ..	2 0	3 7
Warwickshire Drooper	Sel. (Large) ..	4 4	5 9
	Sel. ..	3 6	5 4
President	Sel. (Large) ..	4 6	5 10
	Sel. ..	4 0	5 2
Cluster Damson	Sel. ..	1 9	3 2

Note.—The cost of storage when a moderate quantity of fruit is stored can be put down at 4d. a 12 lb. chip. (See Report for 1936, p. 288.)

* Kidd, F. and West C., "The Cold Storage of English Plums", Department of Scientific and Industrial Research Food Investigation Leaflet No. 1.

Natural Storage—Apples.

General.—Owing to the lack of fruit suitable for gas storage one of the chambers was available for use as a natural store for those varieties of apples for which cold storage was not desirable. Having other chambers on either side in use as gas and cold stores respectively the temperature remained fairly constant between 40° and 45° F. and was excellent for the purpose. As there was no circulation of air for refrigeration it was found possible to keep apples, which normally tend to shrivel badly, such as Orleans Reinette, plump and in perfect condition until required for market.

Wrapping Experiment.—Claims having been made that ordinary newspaper is an excellent medium for wrapping apples and that it is possible to keep apples stored in this way in sound condition over a much longer period than otherwise would be the case, a small experiment, likely to be of more interest to the householder with a few trees in his garden than to the commercial fruitgrower, was carried out to test this theory.

Two varieties were chosen—Bramley's and Allington, the latter because of its proneness to shrivelling. These were divided into equal lots and stored in orchard boxes in three different ways:

(1) Boxes lined with several thicknesses of newspaper and each apple wrapped in newspaper, layers of newspaper also being placed on top.

(2) Left unwrapped.

(3) In oiled wraps. To see how the method compared with ordinary commercial practice.

The results are given in Tables III and IV.

As regards the Allington, there was little difference between the fruit wrapped in oiled wraps and newspaper. Both were markedly superior to the lot that was left unwrapped, both as regards rots and shrivelling. What shrivelling there was in the

TABLE III.

ALLINGTON PIPPIN.

Stored early October, 1937. Date of Examination 7th January, 1938.

Grade and Treatment.	Total apples in box.	Sound or very slightly spotted.	Marked spotting.	Rots.	Shrivelled.	Remarks.
2½ to 2¾ Fancy.						
Unwrapped ..	155	50	21	84	44*	Shrivelling often severe.
Oiled Wraps ..	155	102	40	13	25	Shrivelling very slight.
Newspaper (1) ..	155	106	39	10	8	,,
Newspaper (2) ..	155	97	46	12	3	,,
2¾ to 3 Fancy.						
Unwrapped ..	116	44	16	56	19*	Shrivelling often severe.
Oiled Wraps ..	116	69	36	11	6	Shrivelling very slight.
Newspaper (1) ..	116	72	26	18	4	,,
Newspaper (2) ..	116	67	34	15	10	,,

* This number was undoubtedly actually larger for many of the rots had gone too far to decide whether shrivelling was present.

Table IV.

Bramley's Seedling.

Stored early October, 1937. Date of examination 28th January, 1938.

Grade and treatment.	Total apples in box.	Sound or very slightly spotted.	Marked spotting and rot just started.	Rots over ½ in. square.	Shrivelled.
3¼ *to* 3½ *Fancy.*					
Unwrapped ..	174	39	61	74	Nil
Oiled Wraps ..	174	72	68	34	,,
Newspaper ..	174	46	81	47	,,

wrapped fruit was very slight, the great majority of the fruit being remarkably plump and firm whereas there was a marked tendency to shrivelling amongst the unwrapped fruit. In the 2½ to 2¾ inch fruit there was definitely more shrivelling amongst the fruit wrapped in oiled wraps, but this was not confirmed with the 2¾ to 3 inch fruit. Both methods of wrapping appeared to help in checking the development of lenticel spot, which was very marked in Allingtons here this year.

With Bramley's oiled wraps gave better results than newspaper.

The fruit was stored under good conditions. It is proposed to repeat this experiment another year.

We should like to acknowledge the advice and assistance in all storage matters given by Dr. Cyril West, of the Ditton Laboratories. (A.C.P.)

Table V.

Yields and Average Prices for Certain Varieties of Apples, 1937.

Variety.	Approx. quantity marketed, bushels.	% National Mark fruit.	Average Market Price per bushel.	Remarks.
			s. d.	
Beauty of Bath ..	105	35	7 10	
Grenadier ..	115	69	6 4	
Worcester ..	1,290	69	7 11	
Derby ..	540	60	4 11	
Allington	180	20*	5 5	Cold stored. Marketed December and January. Much lenticel spot, bitter pit, etc.
Cox	225	53*	19 0	Cold stored. Marketed December and January.
Blenheim	45	—	8 7	Cold stored. Marketed January.
Laxton's Superb ..	50	—	9 3	,, ,, ,, ,,
Newton Wonder ..	115	63	8 8	Cold stored. Marketed January and February. Considerable amount of bitter pit.

* The percentage of National Mark fruit would have been somewhat higher but for a certain amount of shrivelling that took place in store.

Table VI.

Yields and Average Prices for Certain Varieties of Plums, 1937.

Variety.	Approximate quantity marketed, ½ sieves.	% National Mark fruit.	Average Market Price per ½ sieve, 24 lb.	Remarks.
			s. d.	
Rivers' Early	265	35	7 5	
Czar	810	23	3 6	
Purple Pershore ..	130	5	1 11	
Pershore Egg ..	195	51	2 0	
Victoria	765	44	4 0	
Cambridge Gage ..	32	84	10 6	
Giant Prune (from tree) ..	165	70	4 2	
Giant Prune (cold stored) ..	133		8 4	
Warwickshire Drooper (from tree) ..	57	69	7 0	For stricter price comparison between fruit marketed direct from tree and cold stored fruit see Storage Notes on page 26.
Warwickshire Drooper (cold stored)	11		10 6	
President .. .. (from tree)	113	79	7 7	
President .. .. (cold stored)	88		11 0	

Hops.

(Area under cultivation, 9 acres, 5½ acres of Professor Salmon's seedlings in Egham Field, 3¼ acres devoted to cultural trials in Church and Egham Fields, ¼ acre of commercial varieties in Upper Grub. About 1½ acres were not in full cropping.)

Weather conditions during the winter made it impossible to carry out cultivations until well into the spring. Nevertheless the hops made good growth which was only checked by the dry weather in July and August.

At no period was Downy Mildew much in evidence. Three sprayings with Bordeaux mixture were given and the crop was picked free from disease with the exception of a very few highly susceptible seedlings which were slightly attacked on the cones.

Aphis was very plentiful in the early part of the summer, but two washings with nicotine and soap gave a satisfactory control.

Yields of nearly all varieties were rather lower than in the previous season, due largely to the fact that more bushels of green hops were needed to give a cwt. of dried hops. The "heavy" or "light" weighing of hops appears to be a seasonal and varietal character, which is not materially affected by any cultural treatments so far tried at the Station.

Owing to favourable weather conditions it was possible to pick the entire acreage, and the total growth amounted to slightly over 6½ tons.

The prices obtained were very similar to those of the previous season. Brewers Gold (C9a) again realized the highest price (£11 per cwt.).

Three pockets of the early seedling P13 made £10 per cwt. Five-and-a-half pockets of Quality Hop (OO63) fetched £9 10s. per cwt. Seven-and-a-half pockets of Brewer's Favourite (OP21) were valued at £9 per cwt. Our growth of Fuggles (7½ pockets) made £8 10s. per cwt.

Mixed growths, other than Manitobas and New Mexicans, realized £8 5s. per cwt., whilst the latter two types made £8 10s. per cwt. The lowest price was realized by the seedling OV7 at £7 per cwt., but this was an increase of 30s. over the previous season's prices. (F.H.B.)

Routine Spraying Programme.

Advantage was taken of very favourable weather for spraying in December, 1936, to get the bulk of the tar-oil work done before Christmas.

Several patches of Capsid markings had been noticed during 1936 in spite of the spraying with winter petroleum done in March of that year. It was decided, therefore, to increase the concentration of oil from 5 to 6 per cent. in 1937 and to spray all apples. Very little Capsid was seen during the year, but it is uncertain how much of this improvement is due to the increase in oil concentration and how much to the cumulative effect of spraying. Excellent control of Red Spider was obtained and it was only towards late summer that "rusty" patches on foliage here and there were evident. These were found mainly on trees retained as unsprayed controls for the summer lime-sulphur treatments, and colonies had slowly been built up on them, probably from a few winter eggs missed by the petroleum.

April weather was, on the whole, wet and very favourable for early Scab-infection. Spring spraying with lime-sulphur was, however, pushed well forward and up to blossom-time the plantations were free from Scab. Because of this, weak post-blossom applications of lime-sulphur proved sufficient to keep the trees clean, and the crop was thus remarkably Scab-free. Instead of the usual two post-blossom applications of lime-sulphur (1 per cent.), at petal-fall and three weeks later, three applications were made. Two weeks after that (1 per cent.) at petal-fall, and again about two weeks later, ¾ per cent. lime-sulphur was applied. This procedure resulted in shortening the period during which any one spray-application must remain effective, and further, it lessened the risk of the fruit-drop that often results when 1 per cent. lime-sulphur is applied in mid-June.

Bordeaux mixture was reduced in strength for pears from 8-12-100, as hitherto used, to 6-9-100. This reduction failed to obviate severe skin-burning of the young fruits, which renders necessary a further reduction in strength or the use of some other fungicide.

Codling was more troublesome on apples than it has been in recent years; this points to the need for spraying against the pest in 1938.

Aphis was very troublesome on hops and several applications of nicotine were necessary to control it.

The Research Station reference number of each of the plots sprayed is given among the details below to facilitate comparison of the sprays applied to any one series of plants throughout the season.

The symbols used for the sprays are :

B.M.	Bordeaux mixture.
L.S.	Lime-sulphur.
A.	Lead arsenate paste.
N.	Nicotine.
S.S.	Soft soap.

All sprays are referred to in quantity of concentrate used in 100 *gallons.*

Routine Spraying Programme, 1937.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
15th Dec. 1936—15th Jan. 1937.	**Tar-oil emulsion** (5 gals.).	Apples, Pears, Plums, Cherries, Black and Red Currants and Gooseberries.	**Aphis.**	All plots. Pears included for first time for many years as aphis had become troublesome.
31st Dec. 1936.	**Tar-oil emulsion** (10 gals.).	Morello Cherries.	**Aphis** and **Brown Rot** (*Sclerotinia laxa*).	Plots 29, 35.
3rd-31st March.	**Petroleum-oil emulsion** containing 6 gals. petroleum oil. ½ gal. oleine. ¾ lb. caustic soda.	Apples, including nursery material.	**Capsid** (*Plesiocoris rugicollis*) and **Red Spider** (*Oligonychus ulmi*).	All plots, viz. C2, C3, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 15, 16, 18, 30, 31, 32, 33, 34, 35, Kiln Field, N1, Upper Grub.
13th and 23rd March.	**L.S.** (3 gals.).	Outdoor, trained peaches.	**Leaf-curl** (*Taphrina deformans*).	Plots 17, 18, Great East, Ditton Lab.
7th April.	**L.S.** (2 gals.).	Black Currants (*just pre-blossom*).	**Big-Bud Mite** (*Eriophyes ribis*).	Plots N2, C4.
9th and 12th April.	**L.S.** (2½ gals.) + **A.** (4 lb.).	Pears (*green-bud*).	**Scab** and **Caterpillar.**	Plots 20, 27, 36, 8 (cordons).
13th-22nd April.	**L.S.** (2½ gals.) + **A.** (4 lb.).	Apples (*green-bud*).	**Scab** and **Caterpillar.**	Plots 2, 3, 4, 10, 11, 12, 13, 14, 16, 30, 31, 33, 34, 35, C3, Kiln Field. C2 received 1% **L.S.** + **A.** (0·4%).
16th April.	**L.S.** (2½ gals.) + **A.** (4 lb.).	Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plots 20, 27, 36.
23rd-30th April.	**L.S.** (2½ gals.).	Apples (*pink-bud*).	**Scab.**	As at green-bud, with addition of trees on Upper Grub, which had **A.** (0·4%) as well.
30th April.	**A.** (4 lb.).	Plums.	**Caterpillar.**	Deadman. Strawberries growing underneath so these plums had had no tar-oil.
5th-7th May.	**Flowers of Sulphur.**	Established Strawberries.	**Powdery Mildew** (*Sphaerotheca humuli*).	Plots 3, 22, 28, Deadman, Upper Grub, and Merryweather.
7th-8th May.	**B.M.** (6 lb. bluestone, 9 lb. hyd. lime).	Pears (*petal-fall*).	**Scab.**	Plots 20, 27, 36.

Routine Spraying Programme, 1937 (*continued*).

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
13th May.	**N.** (5 oz.) + 0·25% **Soap** (1 qt. oleine, 6 oz. caustic soda).	Blackberries.	**Aphis.**	Plot C5a.
14th-20th May.	**Derris** (2 lb.) + 0·25% **Soap.**	Plums (*post-blossom*).	**Red Spider** and **Plum Sawfly** (*Hoplocampa flava*).	Plots 21, 29, C4, Newgates headlands, Deadman (including **N.** (8 oz.) for aphis).
21st-31st May.	**L.S.** (1 gal.) + **N.** (8 oz.).	Apples (*petal-fall*).	**Scab, Red Spider, Sawfly** (*Hoplocampa testudinea*) and **Capsid.**	Plots C2, C3, 3, 4, 10, 12, 13, 14, 16, 30, 35, Kiln Field.
	N. (8 oz.) in water.	Apples (*petal-fall*).	**Sawfly** and **Capsid.**	Sulphur-shy and Scab-resistant varieties on the above plots and on plots 8, 11. These include Lane's, Stirling Castle, Early Victoria, Rival, Grenadier, Lord Derby, Beauty of Bath, Belle de Boskoop, Gladstone, Duchess Favourite, Charles Ross. Soap not used because of risk of russeting, following **L.S.** and **A.** used pre-blossom.
2nd and 3rd June.	**N.** (5 oz.) + 0·25% **Soap.**	Hops.	**Aphis** (*Phorodon humuli*).	Plots 26, 27.
	N. (5 oz.) + **S.S.** (5 lb.).	Hops and Loganberries.	**Aphis.**	Plots C5 (hops) and C5a (logans).
4th June.	**B.M.** (6 lb. bluestone, 9 lb. hyd. lime).	Pears (*second post-blossom*).	**Scab.**	Plots 20, 36. Not on Plot 27 because of red currants underneath.
10th and 11th June.	**Flowers of Sulphur.**	Strawberries.	**Powdery Mildew.**	Plot N3.
9th-11th June.	**L.S.** (3 qts.).	Apples (*second post-blossom*).	**Scab** and **Red Spider.**	Plots C3, 3, 4, 10, 12, 13, 14, 16, 30, 31, 33, Kiln Field. Sulphur-shy and Scab-resistant varieties omitted.
18th June.	**N.** (5 oz.) + 0·25% **Soap.**	Hops.	**Aphis.**	Plots C5, 26, 27.

Routine Spraying Programme, 1937 (*continued*).

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
22nd June.	**Derris** (2 lb.) + 0·25% **Soap.**	Raspberries.	**Raspberry Beetle** (*Byturus tomentosus*).	Plot N1.
25th June.	**N.** (5 oz.) + 0·25% **Soap.**	Hops.	**Aphis.**	Plots C5, 26, 27.
28th June-2nd July.	**L.S.** (3 qts.) + **N.** (5 oz.).	Apples (*third post-blossom*).	**Scab, Red Spider** and **Aphis.**	Plots C2, 3, 4, 10, 12, 13, 14, 16, 30, 31, 33, 34, 35, Kiln Field.
	N. (5 oz.) + 0·25% **Soap.**	Apples.	**Aphis.**	Plots C2, 15, 18, 35 (Beauty of Bath and Duchess Favourite only).
1st-5th July.	**B.M.** (10 lb. bluestone, 15 lb. hyd. lime) + **N.** (5 oz.).	Hops (*pre-burr*).	**Downy Mildew** (*Pseudoperonospora humuli*) and **Aphis.**	Plots C5, 26, 27.
9th-28th July.	**Flowers of Sulphur.**	Strawberries.	**Powdery Mildew.**	Plots 3, 22, 23, 28, N3, Deadman, Merryweather. N3 done again 2nd August, also 35.
22nd-24th July.	**B.M.** (10 lb. bluestone, 15 lb. hyd. lime) + **N.** (5 oz.).	Hops (*pre-burr*).	**Downy Mildew** and **Aphis.**	Plots C5, 26, 27.
5th August.	**B.M.** (10 lb. bluestone. 15 lb. hyd. lime).	Hops (*post-burr*).	**Downy Mildew.**	Plots C5, 26, 27.
19th August.	**Flowers of Sulphur.**	Hops.	**Powdery Mildew** (*Sphaerotheca humuli*).	Plots C5, 26, 27.
26th August.	**Flowers of Sulphur.**	Hops.	**Powdery Mildew.**	Plots C5, 26, 27.
26th-28th August	**Flowers of Sulphur.**	Strawberries.	**Powdery Mildew.**	Plots N3, 35, Deadman, Merryweather.

(M.H.M.)

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH SUMMARIES OF PAPERS PUBLISHED DURING THE YEAR

INTRODUCTION

The presentation of our twenty-fifth Annual Report affords a fitting opportunity for a " stock-taking " of our Research programme, both from the point of view of the investigators themselves and from that of the fruit-growing community for whom primarily we are working. The small group of horticulturists who first set out to study the build-up of the fruitgrowers' material with the ultimate object of selecting the best possible plants and of then trying to grow them under optimum conditions, had a modest programme of description, classification, selection, propagation, budding and grafting. They could not foretell the vista of possibilities which would open up in relation to the varietal peculiarities of small fruits, let alone the complicated problems which the study of stock/scion relationships would reveal.

Thus our present programme of work, comprising some hundred projects, grew up naturally from the original objects in view, and to us who have grown up with and developed it, this scheme of research still appears as a logical unity. This correlation of effort towards a common goal is perhaps most easily seen in our investigations on small fruits, and Sections IX, X and XI show how the pomologist, plant breeder, entomologist and plant pathologist are working as a team in an attempt to produce healthy, fruitful plants, to maintain them under optimum environmental conditions, and, finally, to discover the underlying causes of deterioration and resistance. Though each investigator is primarily occupied with his own aspect of the plant's development or reaction, he is, by this method of collaboration, kept fully aware of other converging lines of approach, so that the " plant " or the " causal organism " is not being studied in isolation from the bearing which its environment—climate, soil, nutrition—may have upon the problem.

Our work with the top fruits illustrates very well the growth and ultimate development of a problem into a number of apparently new channels. The rootstock investigations have been in progress throughout the life of this institute and plantations of trees worked on known rootstocks have now been developing for from sixteen to twenty years. We are sometimes asked whether that work is not yet finished and whether we cannot now go on to something else. Apart from the fact that a well tended plantation appears to have a much longer life than was at one time thought, and that we must continue to watch any changes taking place in the behaviour of the tree throughout its life, there remain all the complications of varietal preferences, manifestations of

incompatibility, differential responses to identical treatments, and evidences of resistance to certain functional troubles and specific diseases.

As opportunity offers, each of these lines is being followed up not only with a view to giving the grower ultimately the best possible plant but in the expectation of adding materially to our knowledge of the ultimate sources, mechanism and causes of rootstock effect and so reach a more complete understanding of the plant as a whole. Thus the Pomological (I), Plant Physiological (III) and Biochemical (IV) Sections are all advancing along lines designed not only to give the industry something to utilize and adapt immediately but also to elucidate the more obscure relationships in the functioning of the tree. Again, we are asked, if this is our ultimate object, why do we not make it our immediate aim, and why do we allow ourselves to be side-tracked into apparently minor issues. With the technique at present available for our purposes of investigation it may actually prove quicker and surer to build up the structure from a number of small accretions to our knowledge, each step making the next one easier, rather than to design a highly complex and ambitious investigation at the outset. An outflanking movement is often more successful and results in less attrition than a direct attack.

We are not forgetting the so-called fundamental problems of plant life, whilst we are trying to solve these so-called applied ones which are of direct importance to the fruit grower.

It is often by studying our exceptions—the particularly good or bad combination of stock and scion or the circumstances under which such a combination reacts differently to external conditions—that we get our first suggestions of the general principles which may lie behind, and so we deliberately treasure these exceptions and investigate them in detail.

The prosecution of these ideas entails the increasing utilization of the results of pure science, and, when pure science is not in a position to give the required answer, we either have to try and find it for ourselves or seek the collaboration of some institution better equipped for the purpose. Such work may often be designed to yield some results of immediate practical value and in the end to give the more academic information which was being sought.

Many of our apparently separate projects are designed so as to yield information of this two-fold nature.

The work of our Biochemistry Section (IV) affords a clear example of what we mean. The health and performance of an apple tree depend in large part on the mineral composition of its foliage, in which are manufactured the complex organic compounds later to be built up into the fruit. The refined chemical and spectrographic methods necessary to determine all the twenty-odd minerals present in the leaves can be used immediately for preliminary diagnosis of mineral deficiency in commercial plantations. Plant injection methods, devised for finding out any important part which each of these minerals may play in the life of the tree, are being used for carrying these diagnoses a stage farther. These immediate practical applications, far from postponing the attainment of the more distant ideal, make its realization the more certain by ensuring that the preparatory work is sufficiently widely based.

Again while the investigations of our Insecticide-Fungicide team are seeking immediate palliatives for the various pests and diseases of fruit plants, they are keeping

their eyes upon the problem of insecticidal and fungicidal action as a whole, and upon the interactions between the tree, the disease, the environment, and the spray fluid. Thus, the general question, as to how far an institution of this kind should confine itself to problems of immediate practical importance to the fruit industry or should engage in work of an academic nature, should never arise.

The investigation of almost any practical problem connected with a living plant soon entails work of interest to academic science and there results a constant interchange between pure and applied science to their mutual advantage.

While the primary aim of the Station must always be the provision of the information which scientific investigations can give the fruitgrower about his plants and their requirements, yet we and our fellow investigators can feel assured that, as far as our facilities will allow, we shall endeavour to pursue our problems to the point of evolving the general underlying principles, which in their turn will open up new possibilities to the community we are trying to serve.

I. POMOLOGY

In Relation to Tree Fruits.

ROOTSTOCK INVESTIGATIONS.

The main rootstock trials of apples, pears on quince, and plums, have now reached maturity and routine records of growth and cropping are being maintained thereon. While much is now known of the potentialities of the original rootstocks, much remains to be learnt of the value of the mature trees. Problems of their proper nutrition, cultivation, etc., are always arising. Meanwhile attention is becoming focused upon the new races of rootstocks raised from seedlings bred from known parents with the definite object of combining certain desirable characteristics. Some of these have now been tested intensively for several years, and there are already indications that some of them may be of value.

Much advance has been made in elucidating other aspects of rootstock effect, particularly in relation to stock-scion compatibility, and to the relative parts played by the roots, stems, unions and branches of the trees. (R.G.H. and J.A.)

1. Apple Rootstocks.

Although most varieties bore light crops in 1937, Worcester Pearmain produced a crop of outstanding quality. This afforded a unique opportunity for studying rootstock effect upon this feature. The actual crops were rather less than in 1936, about 3½ bushels per tree on Nos. I and II as compared with 5 bushels.

All these trees in the main trials were planted at 15 feet square eighteen years ago, when it was considered a waste of space to plant trees so far apart on so-called Paradise stock. Already every alternate tree has had to be removed from the Bramley's Seedling orchards, yet once again the remaining trees require further thinning. Even the trees of the weaker growing Lane's Prince Albert on the more vigorous stocks are now too close and will have to be thinned shortly.

During the winter an intensive nursery trial of certain little known layered rootstocks found in commerce, some of them of Continental origin, has been planted with Cox's Orange Pippin as scion. Opportunity has been taken to examine the root systems when the one-year-old trees were transplanted. (R.G.H. and J.A.)

Further records have been obtained on the fifteen-year-old Grenadier trees on Northern Spy and Crab H roots inarched in February, 1934. The influence of the inarched rootstock on growth continues to show very clearly. The forty-two stunted trees of Heusgen's Golden Reinette on No. IX, inarched with Nos. IV, IX and XII in the spring of 1936, have not yet shown any response to this treatment. The inarched stocks have, however, made excellent growth and are now fully established.

(A.B.B., R.G.H. and W.A.R.)

Land has now been set aside for the large-scale planting of Cox and Worcester upon the selected rootstocks (Nos. I, II, IV, VII, IX and XVI) to elucidate the economic aspect of rootstock effect. The stocks have been planted in the nursery and the trees will be worked in 1938. (R.G.H. and J.A.)

Cordon Trials. The Cox's Orange Pippin and Worcester Pearmain single cordons, planted in 1935, have borne a small crop. Despite the very different type of tree relative stock effect upon precocity has proved identical with that already observed upon bush trees. Trees on No. XII have still grown very much more vigorously than on other stocks in the trial, even though summer pruned.

In order to continue comparable treatment throughout all the trees have had to be lowered to an angle of 35° with ground level owing to the fact that the trees on No. XII are already eleven feet long at four years old. (A.B.B.)

Mechanism of Stock Effect. Three stem- and three root-worked seven-year-old Lane's Prince Albert trees upon No. IX, have been excavated complete. There were no apparent morphological differences in the root systems of trees worked in these two ways. (See also 12.) A report upon the accumulated data, from the main trial of which these trees formed a small part, will shortly be published. Meanwhile, records of growth and cropping of the remaining trees, including those on No. XII, No. II and on seedling rootstocks as well as No. IX, are being continued. A further report is in preparation upon the internal structure of the roots and stems of these trees as revealed by photo-micrographs.

The structure of the stem and root of a complete series of three-year-old unworked rootstocks, covering the whole range of Malling apple stocks Nos. I to XVI, has been examined microscopically, in order to study the relationship of root or stem structure to the effect of these stocks on scions worked upon them. With respect to the roots, large structural differences were observed. It is hoped that this knowledge will be of value not only in the identification of existing rootstocks, but possibly in forecasting the potentialities of new rootstocks.

A series of rootstocks raised from crossing Malling Nos. VIII and IX and worked with Lane's Prince Albert, have also been examined. They showed an even wider range in structure than that shown by the series of clonal stocks referred to above.

The root structure of some thirty apple varieties upon their own roots is also being studied. These have so far revealed a greater range of variability in structure than any of the series of rootstocks examined.

In extension of this work, series of quince, plum and cherry rootstocks have been planted to be sectioned at a later date.

Seed has been sown from the fruits of a mature tree of No. XII rootstock, with the object of comparing the root structure of the seedling progeny with that of one year layers from No. XII clone. (A.B.B., E.C.T., R.G.H. and J.A.)

2. Pear Rootstocks.

Pears yielded poorly in 1937, Conference being the only variety to carry a crop. The investigations into the causes of non-setting of blossoms (see 15) were continued for a further season and three papers, two included in Section III of this report, have been written. This work will be developed further and most of the older trees of pear on quince will be used for the purpose.

Dr. Jules Guyot, Conference and Marie Louise, each budded on the shoots of stools of 300 quince seedlings imported from the Caucasus and Turkestan (see 32), have made one season's growth. They show a wide range in vigour and compatibility. The most promising of these combinations will now be planted out in a nursery trial.

The propagation by seed of pear stocks from mother trees of known history has been continued. Methods of grading the progeny are being tried with the object of obtaining some measure of uniformity in their performance. (R.G.H. and J.A.)

3. Plum Rootstocks.

Most varieties in the main field trials bore well in 1937, President and Early Rivers in particular giving record crops.

Owing to the demand for varieties suitable to top-work upon Czar, which has in recent years proved unprofitable, the main rootstock trial with this variety is being used to test the compatibility and crop performance of a series of some twenty high quality plums and gages, with the object of finding one of commercial value for the purpose.

The intensive trial of Victoria and Czar worked on clonal St. Julien, Black Damas and White Damas, Kroosgespruim selections and certain other rootstocks, chosen for possible dwarfing influence, compared with Myrobolan B and Common Plum as standards, is now four years old. The more promising of these stock-scion combinations have been planted as a field trial, while a complete set has been retained in its original position after being thinned. The records of this trial reveal at least two stocks, compatible with both Victoria and Czar, which show signs of producing early cropping, semi-dwarf trees. During the lifting of these trees a study was made of the root systems of the new selections, and the unions subjected to various tests for degrees of compatibility.

(R.G.H. and J.A.)

The trees of Victoria worked high on the stems of certain varieties, some of which have been found resistant to Bacterial Canker, have made good growth in their second season after transplanting.

Their vigour and cropping will be recorded in addition to relative susceptibility to the disease. (See 74.) (R.G.H., J.A. and H.W.)

4. Peach Rootstocks.

The thirteen-year-old Hale's Early peach trees on a range of rootstocks planted against a board fence have borne a further few fruits but insufficient to warrant retaining them for crop records. They will be lifted and weighed when opportunity offers.

In 1936 buds of Hale's Early were inserted into the rootstocks Brompton and Myrobolan B from 24th June to 26th August, at weekly intervals, in order to test the effect of time of budding upon bud-take and growth of the maiden. The growth resulting from these buds was recorded from time to time during the summer of 1937. The Brompton rootstock produced normal healthy trees whilst the trees on Myrobolan B, though they grew well early in the season, ceased growth towards the beginning of August and demonstrated the usual signs of incompatibility. Growth of the maiden trees was not affected by the time of insertion of the buds. These results are set out in detail elsewhere in this report. (See p. 154.) (R.J.G.)

5. Cherry Rootstocks.

Sweet Cherry Scions. Whilst Turkey Heart bore little more fruit in 1937 than in 1936, there was a substantial increase in the crop of Early Rivers ; even Bigarreau de Schrecken, though still considerably injured by Bacterial Canker, gave a satisfactory crop. The order of cropping on the various rootstocks was somewhat different from that of 1936 ; some of the differences suggest the possibility of a biennial habit. Rootstock influence on weight of crop does not at present seem to be closely correlated with influence on vigour of growth ; trees on one vigorous rootstock have cropped more heavily, and on another less heavily, than trees on rootstocks of medium vigour and less.

A nursery trial of two scion varieties on rootstocks of two varieties of Mazzard and one of acid cherry has quickly shown the comparative dwarfing influence of the acid cherry stock.

Acid Cherry Scions. After two "off" years, due to the spring frosts of 1935 and 1936, it was perhaps natural that crop anticipations ran high in 1937. Though the crop of both Morello and Kentish Red was good, it did not exceed expectations, and this although the Kentish Red crop was the heaviest ever picked from the trees. The Morello crop was particularly patchy, varying from 3 lb. to nearly 80 lb. per tree in different parts of the plantations. In general, the larger trees bore the heavier crops; trees on vigorous rootstocks yielded far more per tree than those on weaker rootstocks. Differences in fruit size were again recorded, and appear in certain cases to be due to rootstock influence.

Most of the Morello trees in the Mazzard rootstock trial, kindly planted for us by Mr. D. J. Moor at Teynham, grew well; on one stock, however, seven trees out of thirty either died or failed to grow, and were replaced, whilst only one of the remaining 120 trees (on four different rootstocks) died. Present indications of vigour of growth show that the stocks come in almost the same order at Teynham as at East Malling.

(N.H.G.)

Ornamental Flowering Cherries. One variety has in the past year been added to the collection planted near the buildings. None of the varieties yet shows any sign of incompatibility with the various Mazzard stocks on which they are worked.

(R.J.G. and N.H.G.)

PROPAGATION.

6. Preparation of Experimental Material.

The collection and testing of new rootstocks for ease of vegetative propagation has been continued. Small units of the new Woolly Aphis immune apple rootstocks have been planted out and budded with the variety Lane's Prince Albert with a view to obtaining some indication of the compatibility of these rootstocks with this variety. Meanwhile a further crop of shoots from the parent stools has been earthed up and these stools will be retained in position for a further season before final selections are made. (See 30.)

The buds of the pears inserted into stool-shoots of seedling quince, originally obtained from the Caucasus, have produced sufficient maiden trees for compatibility studies. A proportion of these trees will be subjected to laboratory tests (see 8), and the remainder will be planted out in nursery rows for further observation. (See 2 and 32.)

The investigations in connection with the technique of vegetative propagation and the effect of chemical "growth substances" upon the rooting of cuttings and layers have been continued in collaboration with the Physiology Section. (See 65.)

Upwards of three thousand apple and quince rootstocks have been planted in order to provide material for the study of causes of variability in nursery material. The work will be undertaken in collaboration with the Statistical Section. (See 63.)

Numerous sets of experimental trees have been raised during the year, notably for the Pomology, Plant Breeding and Physiology Sections and also for Climatological Plots in various parts of the county. (R.J.G.)

7. Nursery Technique Trials.

Investigations during the past six years at East Malling into the effect of presence or absence of the wood in the bud-shield have shown that, though "take" of buds may

vary from year to year, there is little or no advantage to be gained by removing the wood. In general all buddings in the Station's nurseries are now made with the wood left in the bud-shield. Similarly the majority of the buds inserted in nursery rootstocks are now tied with rubber budding-strips as these are considered satisfactory. It appears that it is not yet possible to obtain an inexpensive reliable strip from commercial sources in this country and resort is made to strips cut from selected used bicycle tubes.

In order to test the effect of sealing newly inserted apple buds with petroleum jelly, buds of Cox's Orange Pippin were inserted into 320 No. II apple rootstocks in 1936. Half of the buddings were immediately covered with petroleum jelly and half left uncovered. One hundred and fifty maiden trees were grown from the treated buds whilst the untreated gave rise to seventy-seven maiden trees. So far as could be seen this difference was not due to the depredations of the Red Bud Borer (*Thomasiniana oculiperda* Rübs.) which was not found in the nurseries in the summer of 1936 or 1937. It is thought that the petroleum jelly may have had some beneficial effect upon the buds, in addition to the possibility of having prevented bud borer damage. Further trials are necessary to prove whether this is so. (R.J.G.)

8. Compatibility and Incompatibility between Stock and Scion.

A comprehensive report on the special investigations concerning stock-scion compatibility has recently appeared. (See Summary, p. 62.) Certain of these lines of work are being continued. The principles elucidated are now being applied to the problem as it affects rootstock trials in general. (See 2 and 3.) (R.G.H. and W.T.C.)

Apart from rootstock trials the methods of testing for compatibility, as shown by strength at union for example, are being developed in relation to frameworked trees. (See 9.) (R.G.H. and R.J.H.)

The intensive study of incompatibility completed during the past year, and referred to above has shown that, although comparatively good or bad "takes" may be obtained in different years, environmental factors do not generally have a lasting effect upon compatibility. However, the material raised annually for the study of the effect of climatic factors upon compatibility and variability of nursery material, has proved so useful for demonstration and other purposes, that the present series, with a slight change in varieties used, will be continued for a further period of years. (R.J.G. and T.N.H.)

9. Top-working and Frameworking Methods for Mature Trees.

The thirteen-year-old Newton Wonder trees worked with Laxton's Superb in 1935 in four ways, three methods of top-working and one of frameworking, have borne their first crop. The frameworked trees carried an average crop of some 4 bushels per tree. Of the three top-working methods, the heaviest cropping trees bore an average of between 5 and 6 lb. of fruit per tree. A progress report on these results is being prepared for publication.

Further top-working and frameworking trials carried out during 1937 have involved the grafting of Cox's Orange Pippin upon the varieties Lane's Prince Albert, King Edward, Beauty of Bath and a few trees of sixteen other varieties. Worcester Pearmain also was frameworked upon five varieties. The first year's growth of all these scions has been quite satisfactory. A few of the unions on the framework of all the batches of trees grafted will be subjected to breakage and other tests in an attempt to judge the suitabilities of the various scion combinations. (See 8.) (R.J.G. and R.J.H.)

A ten-year-old Early Amber cherry tree frameworked with ninety scions of Bradbourne Black in 1935 bore a first crop of 33 lb. of excellent fruit in 1937.

The search for economic and efficacious graft seals continues. No improvement upon those already in common use has yet been found.

The pruning of frameworked trees requires further study. It appears to be necessary to prune as little as possible in the first one or two years after grafting, in order that the return to fruiting may not be delayed. (N.H.G. and R.J.G.)

ROOT DEVELOPMENT.

10. Root Growth Investigations.

Observations on the root growth of apples on stocks I, IX and XVI have been continued at monthly, instead of weekly, intervals in our glass-walled root-observation trenches. Data on the seasonal root growth cycle are now available on these three stocks for five consecutive years. This work is being written up. Further observations on the thickening of the roots behind the glass windows are being made, by means of a microscope with a graduated eyepiece. Plans for new experiments with the observation trenches are under consideration. (W.S.R. and C.P.F.)

11. Soil Moisture Meters.

Six of the direct-reading soil moisture meters, developed here, have been in operation throughout the year in fallow land and in clean cultivated and grass orchards. Their records have confirmed those obtained in previous years. Ten more meters have been used in various other field trials, including an irrigation trial of strawberries. In the latter trial interesting information was obtained concerning the downward and sideways spread of the irrigation water, and the use of the water by the plant roots. Further laboratory work on the movement of soil-water has been carried out.

Information has been received that several of these soil moisture meters, installed at the Sub-tropical Horticultural Research Station, Nelspruit, Union of South Africa, have been working satisfactorily. (W.S.R.)

12. Tree Excavations.

The root habit of stem- and root-worked trees of Lane's Prince Albert on No. IX has been investigated by the detailed excavation of six-year-old trees. Two trees, one stem- and one root-worked, were excavated by the skeleton method and were reconstructed and photographed. Four trees, two stem- and two root-worked, were excavated by the block method and the roots from each section graded and weighed. No appreciable differences in the structure or distribution of the root systems of the stem- and root-worked trees were found, thus confirming the records of the growth and fruiting of the above-ground portions of the trees which show that the typical rootstock influence is present in both stem- and root-worked trees. (See 1.)

Twenty-four apple trees of Early Victoria, worked in 1934 on five-and-a-half-foot intermediate stem pieces of Normanischer Cider Apfel and Early Victoria which had been budded in 1932 upon rootstocks Nos. IX and XII at three inches above ground level, were excavated in detail. The intermediate stem piece of Normanischer Cider Apfel, a German stem-builder variety, was found to have influenced the size of the No. IX root system to a certain extent causing it to be slightly larger than when worked direct with Early Victoria. Although it had reduced, it had by no means eliminated, the difference in size between the root systems of Nos. IX and XII. Apart from this effect

on the size, the Normanischer Cider Apfel intermediate appeared to have had little influence on the characteristic appearance normally associated with the root systems of Nos. IX and XII. (See 1.)

Twelve apple trees, ranging from seven to ten years old, of six varieties raised on their own root systems were excavated in detail by the skeleton method and were reconstructed and photographed. The root systems of the six varieties, Newton Wonder, Lord Derby, Bramley's Seedling, Worcester Pearmain, Lane's Prince Albert and Cox's Orange Pippin, varied greatly from one another. The main differences were in (1) size, (2) fibre, (3) colour, (4) brittleness, (5) position. (See 1.)

Two plants of Himalaya Berry were excavated in detail in the autumn. One of these was a normal healthy plant, whereas the fruiting cane of the other had collapsed and died suddenly while in full bearing in August. The young cane of this plant remained alive. The root system of this plant appeared to be much less fibrous than that of the healthy one and this was partly due to the fact that many of the fine rootlets were dead. Some of the older roots looked dark in colour and unhealthy. There was a fair depth, about 2 feet 6 inches, of good soil beneath both plants. The top and root system were examined for insect pests and fungi but no cause for the trouble has yet been found. The fruiting cane of nine other blackberry plants in the same plot collapsed and died in a similar way in August, 1937. (W.S.R., A.B.B. and C.P.F.)

SPECIAL ASPECTS.

13. Investigations in Biennial Bearing.

The repetition of the trial of " on "- and " off "-year spur-shortening on trees of Early Victoria, mentioned last year, cannot begin to show the effect of the " off "-year pruning until the summer of 1938. The past year has nevertheless yielded one result of interest. It is quite clear that " on "-year spur-shortening (involving the removal of large numbers of fruit buds in the dormant stage) did slightly increase fruit bud differentiation in the present instance, but was not nearly enough to overcome the biennial habit. The records taken in 1938 and 1939 will show whether, as expected, " off "-year spur-shortening has a much greater effect in the same direction. (N.H.G.)

The effect of the frost of 1935 on the biennial habit of apple trees, as shown by the blossom and fruit of 1936 and 1937, has in large measure followed expectation. Trees which should have borne their heavy crop in 1935 changed their year of cropping, with the result that formerly mixed sets of trees are now usually all " in step ".

It was thought likely that the biennial intensity would be increased by the complete prevention of cropping in 1935. In the Pruning Plot, however, the reduced root competition following the removal of the " filler " trees might perhaps have counteracted this effect. The actual crop figures for 1936 and 1937 (blossom records are not available) show that the strongly biennial varieties, Early Victoria and Grenadier, had a higher intensity than before 1935 ; whilst the almost regular bearing Worcester Pearmain is now in a strict sense not biennial at all, at least half the trees having borne more fruit in 1937 than in 1936. Newton Wonder, again, which had almost overcome its biennial habit before 1935, has not returned to it ; most of the trees have a lower intensity now than they had in 1933-4. The same is true of Lord Derby.

On the other hand, Cox's Orange, which before 1935 was irregular rather than biennial in cropping, has in 1936 and 1937 become strongly biennial, with a higher intensity even than Rival. Rival itself is slightly more biennial than before 1935, whilst Beauty of Bath shows no uniform change in intensity. It is probable that the

two factors mentioned above both had some effect on the biennial intensity of the trees. (N.H.G.)

The intensive study of biennial bearing initiated in 1935 is being continued in close collaboration with the Physiology and Biochemistry Sections. (See Sections III and IV.) (R.G.H., M.C.V. and P.K.S.)

14. Double Working of Fruit Trees.

Apples. Nursery Trial of "Stem-Builder" Varieties as Intermediates.

This trial, concluded during 1937, yielded certain definite results. All the trees were stem-worked about 3 inches above ground level, and again 5 feet above the first union. It is clear that the "stem-builder" stems do sometimes reduce rootstock influence measurably; the trees of Early Victoria on Nos. IX and XII were less different in size where the stem was a stem-builder variety (and particularly Normanischer Cider Apfel) than where it was Early Victoria. But it is also clear that rootstock influence still predominates; trees on No. IX are still weak and crop quickly, whilst those on No. XII are much more vigorous and slower to crop.

The reduction of rootstock influence by the stem-builder stems was much more plainly shown where the second scion was Early Victoria than where it was Newton Wonder; but this may be in part due to the fact that the Newton Wonder trees were severely pruned after one year's growth, whilst those of Early Victoria were left unpruned.

A report is in preparation. (R.J.G. and N.H.G.)

Other Apples. The oldest double-worked apple trees, planted when the second scions were one year old at the end of 1919, are now somewhat overcrowded. It is planned to remove diagonal trees throughout the four rows; the opportunity will be taken to record as far as possible the weight of the stock, the intermediate, and the second scion. (N.H.G.)

Pears. Nursery Trial. The nursery trial of double-worked pears on vegetative pear and quince stocks, the intermediates being Orange Bergamotte and Pitmaston Duchess, has given further interesting data. Whilst the second scions of four varieties are all much dwarfed by the Orange Bergamotte intermediates, and apparently even more on pear stock than on quince, their production of blossom and fruit has been little more than that of the much more vigorous trees on Pitmaston intermediates. Their dwarfed growth is closely comparable with that produced by apple scions on Metz stocks; but their precocity is certainly not. (R.J.G. and N.H.G.)

Other Pears. All the older pears had a very definite "off" year in 1937. One second scion variety, Marie Louise, has cankered so badly in the past two seasons that the trees are now of little value. (N.H.G.)

15. Non-Setting of Pear Blossoms.

In view of the intensive study of this subject described below, and the fact that the trees of Marie Louise are now so badly cankered as to make them of little value for the purpose, special observations on these, and on the fourteen-year-old trees of Comice, have been discontinued. In the single U cordons of Comice and Glou Morceau grown as "sap transfusion" experimental trees, the Glou Morceau half of the tree has in many cases outgrown the Comice to such an extent that they have had to be bent over into a horizontal position. So far there has not been sufficient crop to give any results. (N.H.G. and N.B.B.)

The special study of factors influencing the setting of pear blossoms is continuing. Accounts of the investigation, which has now been in progress for two seasons, have been written. (See Section III.) This work will be considerably extended. (See 17 and 40 (*e*).) In conjunction with climatological studies, intensive records of time of blossoming, size and position of the flower in the truss, fruit set of hand pollinated blossoms and the weekly growth of the fruitlets will be carried out, on a range of shy and free cropping varieties. Dehorning treatments will be repeated. (R.G.H. and D.N.S.)

PRUNING.

16. Apples.

Certain spur-shortening experiments have been continued on trees of Early Victoria in relation to Biennial Bearing. (See 13.)

Differential summer and winter pruning methods have been continued on the apple cordons. (See 1.)

A trial of Cox and Allington upon Nos. I and XVI, trained as dwarf pyramid or Fuseau trees, has been initiated. Two systems of pruning are included.

(A.B.B. and N.B.B.)

17. Pears.

The experiment on the effect of three different methods of pruning on the growth and cropping of nine varieties of pear planted as single oblique cordons is being continued. No significant differences in growth or cropping between the three methods are yet apparent. Marked varietal differences in habit of growth are beginning to appear, Marguerite Marillat in particular proving to be a difficult variety to train as a cordon owing to its markedly tip-bearing habit of growth. (N.B.B.)

Further records have been accumulated upon the two pruning experiments now in their sixteenth and tenth seasons. Owing to the generally poor crops in 1937 it is not possible to add anything further, except that in the younger series good crops of Amanlis, Fertility and Catillac were obtained on those trees the leaders of which have been lightly pruned.

Drastic dehorning having been shown to improve the set of Pitmaston in 1936, further dehorning trials are being planned with other varieties. (See 15.) (J.A.)

18. Plums.

The double-worked Victoria trees, planted with the object of controlling Bacterial Canker, have been pruned at two different times to study the effect of spring and autumn pruning on the incidence of the disease. (J.A. and H.W.)

19. Cherries.

Owing to the irregular and patchy crop, already referred to under 5 above, of the Morellos, the loss of crop due to the dehorning of the second half of the trees in 1936 cannot be satisfactorily estimated. Many of the trees, however, showed a good recovery in cropping. Growth was again generally satisfactory. (N.H.G.)

THINNING.

20. Apples.

Half the trees of Lane's Prince Albert on Nos. I, II, IX and XVI have had their fruit thinned from 1934 onwards while the other half have been left unthinned. A comparison is being made of the results. (A.C.P.)

21. Plums.

The results of the experiment started in 1936 have now been written up.

(A.C.P. and B.L.W.)

MANURING.

22. Apples.

There was again a good crop on the Cox's Orange Pippin and Beauty of Bath in the trial in which the effects of nitrogen, potassium and phosphorus are compared.

The dying back which had begun in 1936 became very much worse and some trees died almost to the crutch on plots that have not received potash. It is not clear at the moment, however, whether this is only a direct effect of lack of potash or is also connected with drainage, as the plot has been very wet during the last few winters. That of 1936-7 was an especially wet one. The whole question is being thoroughly investigated.

Remedial measures were begun in the late winter as a result of consultation with Dr. T. Wallace of the Long Ashton Research Station and Dr. E. M. Crowther of the Rothamsted Experimental Station. All plots were given a dressing of sulphate of potash at the rate of 2 cwt. per acre. During the summer there was, with Beauty of Bath on rootstocks Nos. I and IX, less marginal leaf scorch than in 1936, but on No. V there was very little less on the plots which had originally received potash and actually a little more on those which had not received any till 1937. As in previous years the trees on No. I had been more, or only slightly less, scorched, than on No. V, it appears that the reduction on Nos. I and IX was the result of manuring rather than a seasonal effect. The reduction was considerable on the plots which had originally received potash, but less on the others.

The possibility that the health of the trees might be partly accounted for by lack of humus was also considered. At the beginning of the experiment it was decided to prepare humus as low in nitrogen content as possible, to be applied when the trees needed it. This material was now too much broken down, but other specially rotted farm waste was available and has been applied at the rate of 10 tons to the acre to half the plots receiving each inorganic treatment. This will be repeated annually until it is thought that the soil is in a satisfactory condition again as far as organic matter is concerned. During the four years preceding the beginning of the experiment the ground received no organic manure. Oat and corn crops were grown to equalize the manurial state of the ground and, as far as possible, deplete it of reserves. Since the experiment began cultivation has been thorough and continued into the autumn, in order that the amount of weed growth should be small. If the routine cultivation of other plots were given here, there would be, by the winter, a very considerable bulk of organic matter with some treatments and little with others.

In the experiment with Cox's in cold store, begun in collaboration with the staff of the Ditton Laboratory in 1936, only the fruit from the trees on rootstock No. IX was used as there was not sufficient from those on other rootstocks. Fruit from each of the manurial treatments was stored at five temperatures—34°, 37°, 40°, 50° and 60°, and was examined at intervals throughout the storage periods. The beneficial effect of potash was strikingly brought out and is more fully dealt with in the Annual Report of the Food Investigation Board for 1937. As a result of tasting by a small panel of tasters it was found that on the whole the fruit from treatments containing potash had a better flavour than that from treatments where potash was omitted, and of the former group that receiving nitrogen, phosphate and potash was the best.

In 1937 it was possible to take fruit from trees on the whole range of rootstocks, Nos. I, V, IX and XII and, in the light of the previous year's experience, the number of temperatures was reduced.

In the experiment on time of application of nitrogen, in which preliminary results are being obtained by giving sulphate of ammonia to trees of Cox's Orange Pippin at different periods of the year, there was less difference in the appearance of the trees than in 1936, suggesting that the weather may be sufficient to mask the effects of such treatments in some years.

The two older apple manurial experiments were continued.

In that in which the effects of the application of 8 and 4 cwt. of sulphate of potash to previously unmanured trees of Bramley's Seedling are compared, there was again very little difference in the appearance of the trees. The growth made in 1936 was measured during the following winter on sample branches of three stocks—Nos. I, II and V, and showed that there was very little difference in the effect of 4 and 8 cwt. Potash deficiency leaf scorch was practically eliminated and the trouble thought in previous years to have been perhaps due to magnesium deficiency, as a possible result of the heavy dressings of potash, was again very evident. Analyses of affected leaves have been carried out by Dr. Wallace and at this Station and further investigations will be made during the summer of 1938.

In the experiment on the effect of dressings of nitro-chalk on biennial bearing, the Bramley's were in their "off" year and had only a light crop. There was not much difference in the appearance of the foliage with the two treatments (*a*) 5 cwt. each year and (*b*) 10 cwt. in the "on" years only. (W.A.B.)

23. Pears.

The results in 1937 in the preliminary field experiment have confirmed those previously obtained. With an annual dressing of 10 cwt. high grade shoddy and 5 cwt. steamed bone flour, there was no further visible effect on foliage with 4 cwt. sulphate of potash and 3 cwt. spring-applied sulphate of ammonia. The plot was not designed as a manurial experiment and it was rather difficult to tell from observation whether there was any effect on growth. The unit being small it was also difficult to detect any differential effect of manuring on crop weight or size of fruit. At least there appears to be no striking or consistent result. (W.A.B.)

24. Plums.

Trees of eight varieties of Damson on Myrobolan B are being grown on for a preliminary experiment on the effect of various quantities of nitrogen on biennial bearing and delayed fruit ripening. (W.A.B.)

IRRIGATION.

25. Effect of Artificial Irrigation.

A strawberry irrigation trial was carried out in 1937. (See under 11, and 57 (Section X).)

VARIETIES AND CLASSIFICATION.

26 and 27. Apples and Pears.

Certain readjustments have been made in the cordon apple variety collections and certain sets of trees have been thinned out. (H.C.C.)

28. Cherries.

Buds of six varieties, believed to be distinct from any in the variety collection, were obtained in the past year.

No further synonyms have been discovered; on the contrary, two varieties regarded previously as identical, Bradbourne Black and Geante d'Hedelfingen, have proved to be distinct. For this information we are indebted to Mr. M. B. Crane, of the John Innes Institution, who has for some years had trees of both varieties, obtained from us, under glass. Our own trees have proved so highly susceptible to Bacterial Canker that we have never yet been able to obtain fruit of both varieties at the same time. The two fruits are closely similar, differing chiefly in their shape on the suture side, and in the depth of their colour. (N.H.G.)

SPRAYING AND TREE PERFORMANCE.

29. Observations in Collaboration with Insecticides and Fungicides Section.

The relation between tree condition (as influenced by cultivation and manuring) and susceptibility to functional disorders, to diseases caused by parasitic organisms, and to infestation by insect pests, is being given close attention, particularly on the apple manurial plot, but also on trees in sand cultures with different nutrients and on trees injected with various solutions. (W.A.B., M.H.M., R.M.G., H.W. and W.A.R.)

FRUIT BREEDING.

30. Apple Rootstocks.

Progress has been made with the work of raising new varieties of apple rootstocks immune from Woolly Aphis, in collaboration with the John Innes Horticultural Institution. Approximately eight hundred seedlings of proved immunity are under test for propagation characters. Many have been multiplied vegetatively and a small unit from each has been budded with Lane's Prince Albert for a preliminary trial of their compatibility, vigour and precocity. Some of the seedlings show promise of being ready rooting on the stools and of possessing other desirable characteristics. The results, so far, indicate that the hereditary behaviour of immunity is determined by, and dependent on, a certain balance of genetic factors and that it is governed by a number of genes, the action of which is in part complementary and in part cumulative. On the basis of the results, it is possible, tentatively, to postulate a scheme of inheritance which will accord closely with the observed facts. Further results are desirable from inbreeding immunes, and from intercrossing susceptibles which appear to possess factors concerned with immunity. Work designed to test the validity of these conclusions is in progress and further crosses were made.

Records have been continued on trees of Lane's Prince Albert worked on the four immune rootstocks, Merton Nos. 778, 779, 789 and 793, selected from a family, Malling No. II × Northern Spy, raised in 1920. A short paper (E118) dealing with the behaviour of six-year-old trees of Lane's, on Nos. 778, 789 and 793 has been published. It was shown that trees growing on these three rootstocks, while they were all much more vigorous than similar trees on Malling No. IX, differed widely among themselves. Trees on No. 789 had made almost twice as much new wood as those on No. 793 by the end of their fifth year, while those on No. 778 were intermediate. In their sixth year, trees on all these three selections bore more blossoms and more fruit than the trees on No. IX, although, relative to their size, the trees on No. IX were the more prolific.

The trees on Nos. 778 and 789 bore considerably more blossoms and fruit than those on No. 793. Trees on No. 789 were found to be less severely attacked by apple mildew than the rest, while fruits from trees on No. 778 were significantly less severely attacked by apple scab.

The search for new rootstocks of value among seedlings from crosses between the Paradise apple rootstocks has been continued although no fresh crosses have been made. Many seedlings are now undergoing propagation trials, and some show promise of being ready rooting. Certain of the most promising are being worked up in quantity for preliminary budding trials.

A number of layered selections from seedling families of No. IX crossed with a wide range of other Paradise rootstocks, worked with Lane's Prince Albert, have been under observation for two seasons. Interesting differences in vigour and precocity between trees on the different selections are already appearing. A series of rootstocks selected from a family VIII × IX raised in 1923, have been worked with Lane's Prince Albert and a paper (E128) has been published dealing with their influence upon six- and three-year-old trees. Of the nineteen selections, trees on eight made less wood growth by the end of their third year, than trees on the very dwarfing No. IX, while trees on seven had made more wood than those on No. VII, a fairly vigorous rootstock. Although trees on only one of these rootstocks had actually borne more blossoms than those on No. IX, by the end of their third season, estimated on the wood growth produced, eight were more productive. By the end of their sixth season, trees on many of these rootstocks had borne considerable crops of fruit, and, in several the total amount was markedly in excess of that borne by trees on No. IX. Observations of the incidence of diseases and pests failed to reveal any very striking cases in which the rootstock had influenced susceptibility of the scion. A paper (E121) dealing with the morphology of the root systems of trees of Lane's on certain of these VIII × IX rootstocks has been published. Wide differences were found in the relative amount of fibre on the root systems of trees on these rootstocks and in its distribution on the main framework of roots. These variations in the root system were thought to be the reflection of a segregation of genetic factors in the seedlings.

With the object of discovering the extent of the variation in vigour, precocity and other characters, to be expected from large families from crosses between the Paradise rootstocks, four stocks from each of 180 seedlings from two families, IV × IX and IX × VI, were worked with Lane's and have been under observation for several years. They are now showing interesting differences in growth and blossom production.

(H.M.T.)

31. Plum Rootstocks.

Several further families of seedlings from crosses between the common commercial varieties of plum rootstocks were raised. These will be planted out for propagation tests during 1938. A number of families, raised previously, are now undergoing trial for ease of rooting and so far they have not shown outstanding promise. The trial of 180 seedlings of *Prunus divaricata* (seedling Myrobolans) collected in the Caucasus, Asia Minor, etc., has been concluded and a paper (E123) summarizing the results has been published. Only a few of these seedlings were similar in their botanical characters to the four East Malling selections of seedling Myrobolan. In general, the seedlings from any one geographical region showed wide variation. Buds of Czar were inserted into all the seedlings and, although more than one bud was used in each case, all the buds failed to take with a number of the seedlings. Losses due to the trees breaking out after the buds had made considerable growth were also common. There were wide

differences in the vigour and fruitfulness on the different seedlings. This was surprising since the seedling Myrobolans previously tested here have always been fairly uniform. These seedlings were not thought worthy of retention beyond their fourth year.

(H.M.T.)

32. Testing of Imported Wildings.

A number of seedlings of apples, pears and quinces, collected from various localities in the Caucasus and Turkestan, have been under trial for some years to test their possibilities as rootstocks. They have been subjected to tests for ease of rooting. While many of the quince seedlings proved ready rooting, few of the apple or pear seedlings showed promise of being easy to root. A number of shoots taken from the apple stools were artificially infested with Woolly Aphis during 1936 and 1937. Of thirty-two seedlings tested, nineteen proved resistant in both seasons. These apple seedlings may, therefore, have possibilities as immune rootstocks.

The shoots arising from the stools of the 365 quince seedlings were budded, during the autumn of 1936, with the pear varieties, Conference, Dr. Jules Guyot and Marie Louise in order to ascertain whether any of them would prove compatible with the two latter varieties. A paper dealing with the early results has been prepared. Conference did well on most of these quinces although there were wide differences in the amount of growth made. Most of the quinces proved compatible with the variety Dr. Jules Guyot but the amount of growth made was definitely less in many of them than that of Conference on the same stool. A much smaller number proved compatible with Marie Louise, and where the buds grew away very few made sufficient growth to give a satisfactory maiden tree. Anatomical studies are being carried out on some of these trees and others are being planted out.

Several hundred of the apple and pear seedlings, both on their own roots and worked on rootstocks, are growing as cordons in order to test the quality of their fruits.

(H.M.T.)

33, 34 and 35a. Scion Varieties of Apples and Pears and Shortening of the Juvenile Period.

Further progress has been made in raising new scion varieties of apples, combining high quality and good appearance with immunity from Woolly Aphis. A number of further crosses were made and the seedlings are being artificially infested. Several families of proved immunity have been worked on to No. IX and planted out for trial. Further crosses between varieties of apples with fruits of widely different colour have been made in an endeavour to elucidate the inheritance of skin colour in the apple. The attempt to produce new varieties of apples of the Worcester Pearmain type but with an extended season of fruit maturity is being continued. Many seedlings raised in previous years, are now fruiting ; some of them are showing definite promise, and a preliminary selection has been made. Scions from some of the more promising are being stub-grafted on to mature trees to increase the quantity of fruit available.

The study of methods of hastening the fruiting of seedling apples has been concluded for the present and a paper summarizing the results has been published (E122). The working of the seedlings on to the dwarfing and precocious rootstock, No. IX, seemed in every case the quickest and most satisfactory method of bringing them into early bearing. Unpruned trees blossomed more quickly and more profusely than those in which the leading shoots or laterals were shortened. Overworking the seedlings on to mature trees or restricting their roots in pots, appeared less effective.

With the object of raising new varieties of commercial dessert pears, several families were raised from crosses between the best existing varieties. A number of pear seedlings, raised in previous years, have been planted out for fruiting, worked on quince. (H.M.T.)

35B. Pollen Studies.

A detailed study has been made on the effect of different pollens on the growth of the fruits of apples and pears. A paper summarizing this work has been prepared. Very considerable differences in average diameter between fruits of the same variety, on the same tree, pollinated by different pollens, were found within the first few weeks after pollination. These differences tended to diminish in magnitude as the fruits approached maturity, until, in every instance studied, they had become negligible by the time the fruits were ripe. This was found to be due to the dropping from the tree of the smallest fruits during the earlier stages of their development. This work will be repeated and elaborated. (H.M.T.)

MARKET QUALITIES.

36. Marketings.

Investigations are being continued with regard to the different methods for the marketing of fruits with special reference to the influence of such factors as variety, stock, season, thinning, manuring, and cultural operations, and their effect on market value. (A.C.P.)

SOIL TYPES AND PLANT PERFORMANCE.

37. Fruit Soils Survey.

Contact has been maintained throughout the year with the plots already established on the Curtisden and Lamberhurst Series of the Hastings Beds and on the Brickearth and Clay with Flints. Records have been taken and observations made on growth. Though only three years old the trees are already showing considerable differences in amount of growth on the various soils. It is also clear that soil conditions may modify the habit of the tree while very young, as with Cox on No. IX the typical spreading growth has been produced at one centre and more upright growth at another.

A further search has been made for suitable sites for plots on the Lower Greensand, the Hastings Beds and on soils not yet surveyed. Two have been obtained, one on the Sutton Series of the Greensand and the other on the Ladham Series of the Hastings Beds. (W.A.B.)

Special Investigations.

WALNUTS.

38. Field Observations and Testing of Varieties.

Continued observations on certain local trees go to show that good cropping is often associated with late leafing-out. Such varieties usually escape the effect of late frosts, and this is probably an important factor in relation to their fruitfulness. Although the size and quality of the nuts of these trees are not such as to warrant their inclusion in the East Malling collection these late-leafing varieties do definitely confirm recommendations from this Station as to varieties of walnut to plant to ensure more regular cropping.

In 1937 some young trees of East Malling selected English varieties produced excellent nuts, well filled, with good flavour, with good oil content, and well sealed. This confirms our previous estimates of the value of these varieties for cultivation in Britain.

Propagation. The very large walnuts, Bannut, Clawnut, etc. (*Juglans regia maxima*) are usually of poor quality but one excellent nut of this class has come to our notice, and scion wood has been obtained from which several young trees of this variety have been raised for testing.

About 200 young trees of standard varieties were grafted and these should be available for distribution in autumn 1939 and 1940.

It is proposed to graft a moderate number each year so as to maintain a nucleus of our material, and it is hoped that nursery firms will, in future years, be able to supplement these trees in increasing numbers.

Budding in the Open Ground. As it is difficult to obtain buds of the previous season's growth in the right condition, an experiment was planned using buds of the current season to see if it was possible to obtain success with them. Buds were inserted into actively growing young stocks and also on new shoots of cut back older trees, at fortnightly intervals, from mid-July to the end of August, using the patch bud method. Some buds were para-waxed after tying in, and others were not waxed. These buds were frequently examined as to their condition but although most of them appeared quite green for as long as four to six weeks, yet by the end of September not a single bud of the current season's growth was alive.

In regard to buds of 1936 growth inserted, the record is better, but not good, the "takes" being about 20 per cent.

It again appears evident that success in walnut budding in this country is very dependent on abundant warm sunshine and the use of buds one year old.

Although this does not appear very encouraging yet the method has been found worth while here for converting trees up to twenty-five years old to better varieties. If only a very few buds grow, they quickly make vigorous growth and refurnish the tree within two or three years.

Grafting under Glass. This is still the most successful method of propagating the walnut, and can be relied on to give good results, provided good sound scion wood is available.

Only one species, *J. Sieboldiana*, P37/3, and one Paradox Hybrid P 65/1, representing two dissimilar types, i.e. the first being very fibrous rooting and probably making medium sized trees, and the other with less fibre with indications of making big trees, are being grown in quantity for further experiment. Both are comparatively free-rooting on stools.

Other species and hybrids are represented by two stools of each, so that they may be further increased when required.

A certain number of rooted layers have been potted for grafting uniformly with two or more varieties for experimental purposes.

Others are planted to be run up standard high and then budded to form good heads. (A.W.W.)

HOPS.

39A. Testing of New Varieties.

As a result of joint discussions with the hop research workers at the South-Eastern Agricultural College it has been decided to review thoroughly the position of those

seedlings that have been under trial for a considerable period, and to fix a definite period (five cropping seasons) for the preliminary testing of new selections.

It is intended by these means to reduce the total number of seedlings under preliminary trial at any one time to about half the present number (300). This will release ground for trials with clonal races of commercial varieties and for comparative cropping trials with those seedlings that show promise in the preliminary testing. These changes will be made gradually over a period of approximately five years.

During the past season twenty-two new selections from Wye have been planted out in the place of those grubbed. The crop from about 230 seedlings was dried separately for cropping records. Samples of the dried crop of 120 seedlings were collected in air-tight glass bottles for use in determining their preservative value.

The analysis of the 1936 crop showed HH44, a mid-season seedling not previously tested, to be the richest hop with the very high figure of 14·58 per cent. estimated antiseptic substances. The next richest was Q43, a late hop of the American type, with 14·22 per cent.; this seedling has been under trial for several seasons and has given heavy yields combined with a high P.V.; it is being named "Bullion Hop" and introduced into commercial cultivation.

No less than eleven seedlings, viz. HH44, "Bullion Hop" (Q43), "Brewers' Gold" (C9a), BB28, 411, R3/100, R1/9, OQ22, "Fillpocket" (Z62), HH17, and OI47 proved richer than the richest American growth (Sonomas 12·07 per cent.).

The early seedling X35 which has given good results over a long period of years in now being introduced to growers under the name of "Early Promise".

The above work has been carried out in collaboration with Professor E. S. Salmon, who has published a report, and Mr. A. H. Burgess of the South-Eastern Agricultural College, who has been responsible for the analyses.

The data relating to the incidence of Downy Mildew (*Pseudoperonospora Humuli*) on the seedlings, and on selected strains of Fuggle since 1924 have been summarized and a report published (see Summary p. 64).

There has been considerable seasonal variation in the intensity and form of the disease, largely influenced by the spring and summer rainfall. A very close correlation between parentage and one type of infection was noted. Nearly all those seedlings showing infection of the rootstock have been derived from one American variety, the "Oregon Cluster".

Only two seedlings out of the very large number (281) recorded showed marked resistance to the disease in all its forms, and unfortunately neither has proved of sufficient brewing value to warrant its continued growth. Although under East Malling conditions the Fuggle has always shown itself very resistant to the disease, the several strains showed different degrees of resistance.

39B. Cultural Trials.

With "Brewers' Favourite" close planting has again given slightly heavier yields. Owing to the very dense mass of bine on the close planted plots it is difficult to spray efficiently and so control Downy Mildew in years favourable to the disease. An alteration in the method of training the bines of the close planted hills in order to reduce the risk of a severe Downy Mildew attack is under consideration.

The differential response to close planting exhibited by "Brewers' Favourite" and L21 indicate that it is only those varieties with relatively short lateral growth that are likely to benefit from close planting.

The lightly pulled hills of "Brewers' Favourite" and P13 whilst making more bine growth have up to the present failed to give any increase in crop. P13 has also

failed so far (one season) to respond to close planting. All treatments with this variety gave equally poor crops, the trial will, however, be carried on for a few more seasons, as much reliance cannot be placed on the results of a single season.

In the Fuggle trial one strain continues to give rather heavier crops than the other two. Hard and light cutting still fail to influence the cropping, but the lightly cut hills are now getting very high in the ground.

With the seedling OV7 the number of bines trained up each string has again failed to influence the cropping. This is not unexpected in the light of the information obtained from the trial with the weaker growing seedling L21 (see last year's report) in which the number of bines per string had a consistent influence on the cropping only where the hills were very widely spaced. The stopping of the bines at the top wire has been without effect, and the more drastic treatment of stopping at the lacing string will now be employed. The effect of stopping is of interest at the moment, as hop picking machines require bines to be without much " head ". Preliminary experiments carried out indicated that stopping greatly effects the formation of heads.

The plot of " Quality Hop " (0063) has been continued as a uniformity trial for a second season, and will now be used to test the effect of time of cutting the hills, with and without subsequent pulling.

The half acre of O147 planted at normal and wide spacing in the rows is being allowed to become fully established before being used for a manurial trial.

(F.H.B.)

HORTICULTURAL METEOROLOGY.

40. Phenological and Meteorological Records.

(*a*) *Routine Meteorological Records.*

Observations under the Agricultural Meteorological Scheme of the Ministry of Agriculture have been continued.

Summaries of the weather conditions month by month have been contributed to the Kent Farmers' Union Journal and a summary of the year's records is published elsewhere in the Report (p. 158). (H.C.C. and H.M.T.)

An instrument has been constructed and installed for measuring the lifting of the soil surface due to frost. The records are proving of interest in connection with the heaving up effect of frost on newly planted strawberry plants. (W.S.R. and H.C.C.)

(*b*) *Meteorological Records on Nursery Plots.*

See under 8.

(*c*) *Micro-climatology.*

A programme has been drawn up, and the work will be taken up in relation to (*d*) below when facilities are available. (T.N.H. and R.G.H.)

(*d*) *The Study of Katabatic Winds and Air Temperatures.*

The knowledge gained last year of the technique for studying katabatic winds and air temperatures has been applied this year.

Katabatic winds have been investigated in greater detail not only on slopes facing the ordinary wind but on slopes facing away from it, and at an angle to it. Katabatic winds have also been investigated in valleys. The conclusions arrived at regarding the relations existing between the direction of the ordinary or " hill-top " wind,* and that of the katabatic wind, reported last year, have been confirmed this year, and may be summed up as follows. The katabatic wind flows straight downhill unless, as for

* In the Report for 1936 referred to as " upper wind ".

example on or near hill-tops, it is influenced by the hill-top wind, when the direction of the katabatic wind is a compromise between the downhill direction and that to which the hill-top wind, or an eddy caused by it, is blowing. The hill-top wind is able, on the higher part of slopes facing it, to push uphill the air in the first few feet above the ground, and at a lower level to neutralize the force of the katabatic wind and thus produce a calm belt on the slope, called the neutral zone.

Investigations into the minimum air temperatures occurring in fields have shown that the minimum air temperature depends largely on the crop. Fields in which there is grass exposed to the sky give rise to the coldest air temperatures on a radiation night, and fields in which the soil is bare, and tall woods in which the leaf-canopy is complete, give rise to the warmest air. When the crops on a slope are uniform, the air temperature, on most radiation nights, varies with altitude, the lowest places being the coldest. On some radiation nights the lowest places are warmest, an effect caused, it is thought, by a layer of mist. (C.E.C.)

(*e*) *Climatic Studies in relation to Setting of Pear Blossom.*

Suggestive results having been obtained with respect to the effect of shelter, aspect, etc., on the set of pear blossom, this work will be now undertaken on a larger scale. Records of wind velocity, soil moisture and temperature will be obtained over a series of years in artificially sheltered and exposed parts of the same plantation. (See 15.)
(R.G.H. and D.N.S.)

In Relation to Small Fruits.

CLASSIFICATION, NOMENCLATURE AND VARIETIES.

41A. Black Currants.

With the exception of Boskoop Giant, heavy crops of black currants were general in 1937.

In the six-year-old trial of Baldwin planted at 5 ft. × 6 ft., and Wellington Triple X at 7 ft. × 6 ft., the latter are now very large bushes and in 1937 gave the heavier yield, not only per bush (6 lb. as against 4 lb.), but also per acre (58 cwt. as against 48 cwt.).

In the variety trial a year younger, planted at two distances 4 ft. × 7 ft. 6 in. and 6 ft. × 7 ft. 6 in., the close planted plots gave the higher return per acre with all varieties, although the average weight per bush was slightly lower. (J.A.)

41B. Red Currants.

The variety trial of red currants, now in its ninth year, continues to demonstrate that the smaller fruited types, such as La Constante and Houghton Castle, give much heavier yields than the larger fruited types like Fay's and Versailles. This is to a large extent, however, offset by increased picking costs and a lower market price. (J.A.)

42. Raspberries.

See under IX.

43. Loganberries, Blackberries and Dewberries.

See under XI.

44. Strawberries.

See under X.

BREEDING.

45. Black Currants.

Observations have been continued on about 1,000 seedlings raised from seed of Baldwin and Boskoop Giant treated with X-rays or derived from pollen and ovules so treated. This work was undertaken in collaboration with the late Mr. L. Stone of Merton, and it was hoped to produce useful mutations in the material treated. Five years observation has failed to reveal any perceptible mutations among these seedlings. Certain bushes have now been selected as parents for a further generation and a number of families have been raised from them. A plantation consisting of about 1,000 bushes, from crosses between the principal commercial varieties, raised in 1930, has been grubbed after yielding further information on the inheritance of characters. Some promising selections have been saved. The bushes of the interspecific cross between the black currant and *Ribes longeracemosum* again yielded no fruit. An attempt to induce polyploidy in these hybrids by artificial means is being undertaken, in collaboration with the John Innes Horticultural Institution.

Seven seedlings, raised in 1928, and showing promise as possible commercial varieties, have now been propagated in quantity and planted out for a comparative cropping trial against the best existing varieties. (H.M.T.)

46. Red Currants.

This work is temporarily in abeyance.

47. Raspberries.

See under IX.

48. Strawberries.

See under X.

PROPAGATION.

49. Currants.

A clonal disease-free nucleus is being maintained.

50. Raspberries.

See under IX.

51. Gooseberries.

Clonal dessert varieties are being maintained.

52. Strawberries.

See under X.

53. Loganberries and Blackberries.

See under XI.

PLANTING, TRAINING, PRUNING, THINNING.

54. Currants.

Suitable distances and pruning treatments are being tested. (See 41 above.)
(R.G.H. and J.A.)

55. Raspberries.
See under IX.

56. Gooseberries.
Fruit thinning trials are continued as opportunity permits. (A.C.P.)

57. Strawberries.
See under X.

58. Loganberries and Blackberries.
See under XI.

MANURING.

59. Raspberries.
See under IX.

60. Strawberries.
See under X.

PUBLICATIONS DURING THE YEAR.

Hatton, R. G. "The Problems raised by the Woolly Aphis of the Apple. A Case for Team Research. I. Introduction." Ann. Appl. Biol. (February, 1937), **24,** 169-73. (E115).

Hatton, R. G. "The Problems raised by the Woolly Aphis of the Apple. A Case for Team Research. II. The Northern Spy as a Rootstock." Ann. Appl. Biol. (February, 1937), **24,** 173-80. (E116).

Summary.

1. Entomological considerations of immunity to Woolly Aphis were responsible for the introduction of Northern Spy as a rootstock.

2. When the question of stock-scion relationships came to be investigated and comparative tests made between trees on Spy and other rootstocks doubts about the value of the former as a rootstock arose.

3. The results of two small field experiments of bush and half-standard trees of the variety Grenadier worked upon Spy and other clonal rootstocks are brought up to date.

4. At the end of fifteen years the trees on Spy are strikingly less vigorous than those on a number of vigorous and very vigorous layered rootstocks. Summer growth census analyses also reveal differences.

5. The trees on Spy show typical foliage symptoms of potassium deficiency and have become stunted, not normally dwarf, in growth.

6. Whilst the trees on Spy were, with the exception of those on Malling No. II, the most precocious to blossom and crop, they have increased so little in size that they have long been surpassed by trees on most of the other stocks.

7. The fruits of Grenadier on Spy have been smaller and yellower in appearance when compared with those on No. XVI.

8. Fruits from trees on Spy, No. I and OF5 have for three seasons been kept for comparison at Long Ashton throughout their whole storage life. Whilst each year the

fruits on Spy have shown a lower percentage of " rot ", " scald " and " breakdown ", this must be considered in relation to relative maturity at picking. Seasonal effects were much greater than any stock effect.

9. Evidence in literature, and unpublished, suggests that these peculiarities are not confined to the variety Grenadier under the conditions at East Malling. Complaints of unsuitability of Spy are frequent.

10. The writer's personal observations in Tasmania, Victoria, Queensland, New Zealand and South Africa confirm the uncertain behaviour of Spy as a stock, and show that conditions other than environment are the cause of stunted orchards. Trees on seedling rootstocks have been seen to thrive where those on Spy fail.

11. A practical " inarching " experiment in Tasmania, where seedling stocks were introduced into the stems of stunted trees on Spy, strongly suggested that a change of root system could completely reinvigorate trees *in situ*.

ROGERS, W. S. " The Problems raised by the Woolly Aphis of the Apple. A Case for Team Research. III. The Root System of Northern Spy." Ann. Appl. Biol. (February, 1937), **24,** 180-4. (E117.)

SUMMARY.

Investigations on Northern Spy root systems at East Malling Research Station are briefly described. Forty-seven trees of Northern Spy and comparable stocks, Nos. I, II, IV and Ivory's Double Vigour ranging from 3 to 17 years old were excavated in detail.

The root system of Northern Spy was found to be distinctive in that it is usually sparse, one-sided, lacking in fibre, and tending to send down deep roots only at the extremities of the root system. Root competition or other soil factors may make the root system of Northern Spy occupy deeper layers of soil but these roots do not appear to flourish.

TYDEMAN, H. M. " The Problems raised by the Woolly Aphis of the Apple. A Case for Team Research. VII. Pomological Selection of the New Rootstocks." Ann. Appl. Biol. (February, 1937), **24,** 199-205. (E118.)

SUMMARY.

Details of the methods by which seedlings immune from Woolly Aphis are tested as to their suitability as rootstocks for apples are given.

The preliminary propagation tests are described and details of the rooting capacity of some of the families of immune seedlings are given.

Data of the average annual new wood growth, girth of stem, number of blossom trusses and weight of fruit, of trees of Lane's Prince Albert on three selected seedlings, Merton Nos. 789, 778 and 793 from Malling No. II × Northern Spy, are given.

It is shown that trees on these three selections differed widely in their vigour and productivity during the six years that they have been under observation. While trees on No. 789 were considerably the most vigorous by their sixth year, trees on No. 778 bore, on the average, slightly more fruit than those on No. 789 and much more than those on No. 793. All were much more vigorous than the control trees on Malling No. IX and, in their sixth year, bore a larger quantity of fruit.

Differences in susceptibility to apple mildew and apple scab between the trees on these three rootstocks are demonstrated.

HEARMAN, J., BEAKBANE, A. B., HATTON, R. G. and ROACH, W. A. The "Reinvigoration of Apple Trees by Inarching of Vigorous Rootstocks." Journ. Pom. and Hort. Sci., 1937, **14,** 376-90. (E114.)

SUMMARY.

1. The method of inarching apple seedlings has been used commercially overseas for improving the performance of unthrifty apple trees without other alteration in cultural treatment, and with a considerable amount of success.

2. The studies here described showed that inarching vigorous apple rootstocks into the trunk some distance below the branches of established but debilitated apple trees led to a marked increase in vigour by the end of three seasons.

3. The main effect of the inarching was shown by those particular branches of the trees which were in direct vascular connection with the rootstocks.

4. When the rootstock was inarched direct into a single branch, this branch has, up to the present, shown the main or entire effect, and other branches of the same tree have remained unaffected; they may therefore be used for comparison for estimating the effect of the inarching.

5. When the rootstocks were inarched into woody strands which divided at the main crutch and ran into two or more branches, the whole tree was affected.

6. When the trunk has a spiral twist, account of this must be taken when deciding on the point of insertion of the rootstock.

TYDEMAN, H. M. "The Root systems of some New Varieties of Apple Rootstock." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 87-91. (E121.)

TYDEMAN, H. M. "Experiments on Hastening the Fruiting of Seedling Apples." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 92-99. (E122.)

TYDEMAN, H. M. "New Varieties of Rootstock for Plums. II. A Final Report on Seedlings of *Prunus divaricata*." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 100-4. (E123.)

ROGERS, W. S. "Soil Moisture Studies. I. Water Utilization by Apple Trees in Cultivated and Grass Orchard, compared with Fallow Land." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 105-9. (P2.)

ROGERS, W. S. and SRIVASTAVA, D. N. "Soil Moisture Studies. II. Moisture Variation in a Pear Orchard." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 110-113. (P3.)

BAGENAL, N. B., GARNER, R. J. and HATTON, R. G. "A Practical Evaluation of Rootstocks in Commercial Circulation." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 281-4. (E124.)

GRUBB, N. H. "Varieties of Cherries." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 285-7. (E112.)

PAINTER, A. C. "Notes on One Season's Experience with Cold Storing Plums." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 288-94. (E125.)

ROGERS, W. S. "Notes on Strawberry Culture." Kent Farmers' Journ., 1937, **42**, 112-17. (Esf32.)

SUMMARY.

Practical notes are given relating to strawberry culture, with special reference to clonal races, virus diseases, Strawberry Aphis, Tarsonemid Mite, cultural factors, and runner raising.

TYDEMAN, H. M. "Studies on New Varieties of Apple Rootstock." Journ. Pom. and Hort. Sci., 1937, **15**, 165-90. (E128.)

SUMMARY.

This paper describes studies, extending over six years, of trees worked on nineteen selected rootstocks from a family, Malling No. VIII (French Paradise) × Malling No. IX (Jaune de Metz), raised at the John Innes Horticultural Institution in 1923.

It is shown that there was an extremely wide range of variation in vigour between the trees of Lane's Prince Albert worked upon these rootstocks, whether expressed in terms of the new wood made, increase in thickness of the stems or the ultimate weight of the tree.

It was found possible to classify the rootstocks into five "vigour" groups. The rootstocks in two of these were found to exert an even more dwarfing effect on the tree than did the dwarfing Malling No. IX, growing in the same trials. At the other extreme, seven of the rootstocks exerted a definitely more vigorous effect than Malling No. VII at three years old.

A very close relation is shown to exist between the vigour of the trees on these rootstocks and the relative size of the swelling at the union.

When expressed in terms of blossom production, marked differences were found in the relative productivity of the trees on the various rootstocks. A very clear and consistent correlation was found to exist between the "dwarfing" character and the productivity of the trees, the trees on the more vigorous rootstocks being, in every case, less productive, in their earlier years, than those on the more dwarfing rootstocks.

Although, in regard to the actual number of blossom trusses produced by the end of the third year, there was little perceptible difference between the trees on the rootstocks in the three least vigorous groups, it was possible to demonstrate the greater relative precocity of the trees on the most dwarfing rootstocks, on the basis of the blossom trusses produced per unit of new wood growth.

In the first year of flowering, the trees on the most dwarfing of the series bore far more blossom trusses than did the trees on Malling No. IX growing in the same trials.

Records of fruit production by the trees on these rootstocks are summarized and discussed. It is shown that, in general, the conclusions that can be drawn approximate very closely to those already outlined for blossom truss production.

Data are given showing the relative susceptibility of the trees, during a single season, to Leaf Scorch, Scab, Canker, Mildew, Crown Gall and Blossom Weevil. Little evidence of a direct rootstock influence on the degree of attack on the scion could be deduced. A somewhat obscure correlation between the vigour of the tree and the relative freedom of its fruit from Scab is mentioned, and an instance is given of the effect of the severity of Apple Blossom Weevil attack on different rootstocks, due, probably, to the varying times at which the flowers on the trees growing on them opened.

Chang, Wen-Tsai. "Studies in Incompatibility between Stock and Scion, with special reference to certain deciduous fruit trees." Journ. Pom. and Hort. Sci., 1938, **15,** 267-325. (E132.)

Summary.

1. The problem of incompatibility between stock and scion has been studied in deciduous fruit trees, especially in pears, plums, peaches and cherries. 86 grafted and 32 budded combinations of scion-stock, stock-scion and stock-stock have been studied at East Malling during 1935-37. All the rootstocks used were of clonal origin and were vegetatively propagated.

2. All incompatible combinations, grafted or budded, showed a low percentage take, premature autumn leaf-coloration and flower bud formation, early defoliation, and dying back of young shoots. The low percentage take was less noticeable on budded than on grafted plants. Defoliation started from the tops of the shoots in incompatible combinations in contrast to the ordinary defoliation from the basal portion of the shoots in compatible combinations.

3. In all incompatible combinations there was a marked gradual decline of the annual wood growth, usually following an initially vigorous growth at an earlier stage. There was also a gradual decline of new root growth both in number and length. The incompatible combinations started new root growth much later in the spring than the compatible ones. These findings corresponded with the results obtained from excavated trees, namely that the incompatible combinations had an initially higher but subsequently much lower scion/stock ratio than the compatible ones. All these symptoms were intensified in direct relation to the age of the tree and the degree of incompatibility. Moreover, these symptoms occurred both in scion-stock and their reciprocal combinations.

4. All incompatible combinations showed a mechanically weaker union than the compatible ones. This was indicated by :

(*a*) Bark and wood-fibre discontinuity. Incompatible combinations showed three classes of bark and wood-fibre discontinuity, arranged in order of decreasing severity, as follows :

(i) Both bark and wood fibres discontinuous.

(ii) Bark continuous, but wood fibres discontinuous.

(iii) Bark discontinuous, but wood fibres continuous.

(*b*) Heavy accumulation of parenchymatous cells at the union. Compatible combinations possessed regular strands of medullary ray cells across the union about four weeks after budding ; whereas the incompatible ones had much enlarged parenchymatous cells arranged irregularly at the union even up to twelve weeks after budding.

(*c*) Reduced strength at the union and clean surface of break. Incompatible combinations required far less force to fracture the union than compatible ones, and the surface of the fracture was invariably smooth and had a distinctive layer of inwardly curved cells.

5. Incompatible combinations had some form of obstruction at the union. This was indicated by :

(*a*) A slower flow of dyes through the union, as shown by dye injections.

(*b*) A much higher resistance to the flow of water, as shown by water conductivity tests.

(*c*) A heavy deposit of starch above the union in November, as shown by the iodine test.

Mechanical weakness and obstruction at the union are suggested as the immediate causes of the decline of a tree showing an incompatible combination.

6. Some of the physiological functional differences between the scion and its incompatible stock have been studied. It was found that different stock and scion varieties had :

(*a*) Different periods of cambial activity, as observed by the bark-peeling and stripping method, in summer and autumn.

(*b*) Different periods of callus growth and different regions of callus differentiation, as studied in grafts. In incompatible combinations, most of the callus cells which were not in contact died after about a month.

(*c*) Difference in the duration of leaf-expansion from the time of bud-break. The combination was most incompatible when a slow leaf-expanding scion was worked on a quick leaf-expanding stock.

(*d*) Difference in growth curves, as shown by the weekly measurements of the terminal shoots.

The wider the divergencies of such physiological functional differences between a scion and its stock, the greater the degree of incompatibility.

7. It is concluded that a mechanically weak union and the increasing obstruction at the union are the immediate causes of shoot and root decline in an incompatible combination, and that all the physiological functional differences manifested in cambial activitity, callus growth, duration of leaf-expansion, and growth curves of the stock and scion varieties may be accounted as important contributory causes of incompatibility among deciduous fruit trees.

8. It is pointed out that all these physiological functional differences in the growth activities of the stock and scion are inherent, and may be somewhat modified under different climatic and environmental conditions, and this helps to explain the different results obtained in different parts of the world in regard to the occurrence of the symptoms of incompatibility.

BEARD, F. H. " Cultural Trials with Hops. II. The Effect of Distance of Planting and Number of Bines. A Final Report on the Trial with the Seedling L21." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 117-25. (B28).

SALMON, E. S. " Twentieth Report on the Trial of New Varieties of Hops." August, 1937. (B29.)

SUMMARY.

1. Of the 249 varieties (New and Commercial) tested, six new varieties cropped at the rate of over 25 cwt. to the acre, and fifty-five other new varieties at from 20 to 23¾ cwt.

2. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 92 to 153.

3. Twenty-seven of the new varieties proved on analysis to be richer in preservative qualities than the richest old variety (Eastwell Golding, 10·69 per cent.).

4. Eleven new varieties were richer in preservative qualities than the richest sample of American hops obtainable—the highest, HH44, by 2·51 per cent.

5. Notes are given on certain new varieties which are being grown commercially or which show commercial promise.

6. The incidence of Mosaic Disease and of Downy Mildew is recorded.

BEARD, F. H. "Observations on the Incidence of Downy Mildew on New Seedling Varieties of Hops at East Malling, 1924-36." Journ. Pom. and Hort. Sci., 1937, **15,** 205-25. (C140.)

SUMMARY.

An account is given of observations on the incidence of Downy Mildew (*Pseudoperonospora Humuli*) from its first appearance in 1924 until 1936 on certain new seedling varieties of hops and on strains of Fuggle growing in the experimental garden at the East Malling Research Station, the main features of each season's outbreak being mentioned briefly.

The seasonal variation both in intensity and in the form of the disease (mainly spike production and cone infection) is shown to be largely influenced by the spring and summer rainfall.

The incidence of the disease on seedlings of various parentages is recorded, and it is shown that seedlings of certain crosses have, on the whole, had a high percentage of hills bearing spikes. Certain seedlings of *Humulus americanus* and its variety *neomexicanus* have proved very susceptible to attack on the cones.

Some crosses have given rise to very susceptible seedlings and also to others which show some resistance to infection of the bine.

The closest correlation between parentage and susceptibility to the disease is shown by rootstock infection, practically all seedlings severely attacked in this way having originated from the same American variety. Only two seedlings so far tested have shown any very marked resistance to the disease. Of six new varieties recommended for commercial cultivation, some show a measure of resistance to attack either of the bine (or rootstock) or of the cones.

At East Malling, Fuggle has proved very resistant. The data obtained lend support to the view that there are various strains of this variety in cultivation.

Attacks of the disease on the cones have largely been prevented by routine spraying with Bordeaux mixture.

II. STATISTICS AND RECORDS

61. Records.

As in previous years, the summarizing and analysis of records of existing experiments has kept the Section fully occupied, the more so owing to the absence of one member for practically the whole year.

In particular, a great deal of work has been done in preparing for publication seven years' accumulated records on the apple manurial trial. A considerable time was also spent in advising and assisting post-graduate students in the analysis of their data. Another side of the Section's work, which has increased considerably during recent years, is the preparation of diagrams. (T.N.H., J.L.E. and J.S.P.)

62. Technique of Recording.

It has not been possible to extend further the work on sampling, during the past season at the Station, though some of the methods evolved are now, perforce, in regular use. Their usefulness will continue to be checked and improved as opportunity offers.

The records on the experiment in sampling Allington Pippin apples for size and colour have been analysed, and an account of the experiment with conclusions reached is presented with this Report. (T.N.H. and J.L.E.)

In collaboration with the staff of the Division of Horticulture at the Central Experimental Farm, Ottawa, an elaborate experiment in sampling technique was undertaken during the winter 1936-37. The experiment was designed to study the causes of variation in keeping quality of McIntosh Red apples in a uniformly treated orchard, and to use the information so obtained to establish a satisfactory method of sampling. The storage behaviour of some 11,520 individual apples was observed and the records are now in the process of analysis. A report will be issued shortly. (T.N.H.)

63. Experimental Design.

At the request of the Royal Horticultural Society, a study has been completed of five years' records on the co-operative variety trials of black currants, carried out at Wisley, Long Ashton and East Malling, and a report has been issued.
(T.N.H. and J.L.E.)

The records obtained on the performance of some 2,500 individual plants, covering a period of five years, in the strawberry clonal trials have now been examined and a report completed. A subsidiary study of the variation in these plants, and its effect on plot size, number and shape, has also been made and the two reports will shortly be published. (J.L.E.)

An investigation into the causes of variability in nursery trees has been started in collaboration with the Pomology Section. The information obtained will be used eventually when trees are selected for permanent experiments. (H.B.C.)

A considerable amount of experience has been acquired during the last few years with regard to the designing of nursery experiments. This information, of which it is proposed to give an account in due course, will be of great value in designing such trials in the future.

Further experience has been obtained in the design of experiments, under conditions other than those obtaining in this country. It has not only been possible to visit personally a number of Stations, where experiments have been designed by this Section in previous years, but in collaboration with other workers concerned, it has been possible to launch several more in various parts of the Dominion of Canada. The opportunity to discuss personally the various points arising has been of great value.

With the aid of a research grant from the Leverhulme Trust, a tour was made of Research Stations in California and Trinidad, where work is in progress on subtropical and tropical fruit plants. The experience thus gained in the layout and interpretation of experiments on such crops, will be extremely useful in meeting the frequent demands for advice received by the Section from abroad. (T.N.H.)

See also Horticultural Meteorology, 40.

PUBLICATIONS DURING THE YEAR.

Chapelow, H. C. and Tydeman, H. M. "Weather Conditions during 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 114-16. (H29.)

Cornford, C. E. "A Note on Frost Damage Investigations." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 127-30. (H30.)

Hoblyn, T. N. and Edgar, J. L. "A Study of the Technique of Variety Trials, as illustrated by the Comparative Yields of four Black Currant Varieties grown in three different localities." Journ. Pom. and Hort. Sci., 1938, **15,** 326-37. (Esf33.)

Summary.

The yield data of four varieties of black currant over a five-year period secured from an extensive experiment carried out simultaneously at three stations are examined.

It is shown that the experimental design used, namely six four-by-four Latin squares with a four-bush plot as the experimental unit, gave exceptionally accurate results. Large differences were shown not only between the gross varietal yields at all stations, but also in the response at individual stations.

These data were used to determine the best number of replicated plots for use in such trials. It is concluded that whereas from three to four four-by-four Latin squares would be necessary for reasonable precision at a single station, two similar squares would be ample if the experiment were repeated at two or three stations.

III. PLANT PHYSIOLOGY

64. Analysis of Growth Relations of Stock and Scion.

(*a*) *Relative Parts Played by Roots and Stem in Stock Influence.*

The two series of double-worked trees of Stirling Castle on stems and root systems of Malling stocks have been lifted this winter. Final measurements have been made on the trees and the results will be written up for early publication.

In the main the results of this experiment are in accordance with past experience here ; the stock contributing the intermediate stem piece has been found to have some effect on tree performance, but less than that of the stock contributing the root system. (M.C.V.)

(*b*) *Time, Nature and Distribution of Summer Growth.*

Methods for analysis and interpretation of summer growth data, obtained by the " census " method, have been completed and will be ready for publication soon. (M.C.V.)

The results of censuses taken in connection with the investigation into biennial bearing in apples (see (*h*) below) are being analysed. (P.K.S.)

(*c*) *Seasonal Course of Root and Shoot Growth.*

The data from the experiments with the unworked apple stock No. XIII and the worked trees of Cox and Lane on Nos. I, II, IX and XII are being analysed from several new standpoints.

In particular an examination is being made of the relation of tree weight to cross section of trunk and length of new shoots, with a view to determining how far tree weight can be estimated in the field from the normal pomological measurements of trunk girth and wood growth. The data include the records from over thirty harvests of from 20 to 50 trees each, taken at various times in the season over several years. The trees ranged from maidens to three-year-olds.

Further harvests have been taken of the stock-on-stock trees in which the stocks Nos. IV, IX and XII have been combined as scion and stock in all nine possible ways. It has been decided to leave these trees *in situ* in their nursery rows instead of transplanting them at the end of their maiden year. (M.C.V.)

(*d*) *Cambial Activity at the Union.*

Some work on this has been carried out in the Pomology Section. (See 8.)

(*e*) *The Assimilation Rates of Apple Leaves.*

Work on this has not yet been resumed.

(*f*) *Seasonal Absorption of Nutrient Salts by Apple Trees Grown in Water Culture.*

A further series of trees consisting of two-year-old bedded rootstocks Nos. IX and XII were successfully grown in water cultures by the bubbling method. The iron " deficiency " chlorosis which occurred in trees grown by this method (East Malling Report 1936) last year was completely avoided by altering the constitution of the culture solution. The foliage maintained a healthy colour throughout, and the trees of

No. IX increased sixfold in fresh weight during the season while those of No. XII increased twelvefold, and it was possible to show very significant differences in the growth rates of the two stocks with a unit of five trees. The solutions were changed every three weeks, and nitrogen analyses have shown that towards the end of the summer more than half the nitrogen supplied was absorbed during the three weeks. It would therefore be an advantage if the solutions could be changed more frequently, and to overcome the difficulty of obtaining the necessary amounts of distilled water, it is proposed during the 1938 experiment to use rain water, and take blanks for analysis at the beginning of each period. A new series of trees is being started consisting of maiden trees of Cox on IX and XII. (H.L.P.)

(*g*) *Water Relations.*

Work on this has been carried out by the Pomology Section (see p. 62).

(*h*) *Biennial Bearing.*

The intensive study in collaboration with the Pomology (I.13) Biochemistry (IV.68) and Insecticides and Fungicides Sections has been continued, and the trees used for the manipulation treatments will be kept under observation for a number of years to determine the after-effects of the various treatments.

The analysis of the results of the morphological examination of five varieties to determine the relation of fruit-bud formation and the "category" of the growth, and of the results of the manipulation experiments, have been completed. Those of the other Sections of the investigation are being analysed. (P.K.S.)

Further intensive work on this problem is being postponed until the analysis of these results indicates what are the most promising lines of attack. (M.C.V.)

(*i*) *Effect of Deblossoming and Degree of Pruning on Growth.*

An experiment on these lines is being planned in collaboration with the Pomology Section. (M.C.V.)

65A. Vegetative Propagation (in collaboration with Propagation).

The Use of Growth Substances for Rooting Cuttings of Deciduous Fruit Trees.

Experiments are being continued to see if the rooting of cuttings, and layers of various rootstocks and varieties of deciduous fruit trees, which are either difficult to root, or which require long periods to form roots, can be encouraged by treatment with synthetic root-forming substances. The factors governing the response of cuttings to treatment are being investigated, including :—

(1) The physiological condition of the cuttings treated, i.e. the time at which they are taken, and the type of cutting used.

(2) Method of treatment, i.e. concentration of solution, time of immersion, and the external conditions during the treatment period.

(3) Constitution of the rooting medium, and the external conditions during the rooting period.

Softwood Cuttings.

Marked response to treatment with α-naphthalene acetic acid, and indolebutyric acid has already been obtained with certain varieties of plum, and pear rootstocks,

when the cuttings were planted in sand in a heated frame after treatment ; with other varieties, however, no positive results have yet been observed. A note on some of the results during the 1937 season was published (F25).

Hardwood Cuttings.

The experiment carried out last year when only some of the less active substances were available gave no improvement in percentage of cuttings rooting, and the proposed " photoperiodic " treatment was omitted. All the space available on the cutting beds has been used this year for a large experiment with growth substances using cuttings of several varieties of plum, pear and cherry rootstocks. A technique for the treatment of leafless woody cuttings is being worked out using easy-rooting species of willow, poplar and black currant. A paper on the transport of the applied substances in dormant willow cuttings, and the position, and number of the roots initiated after various treatments is now in the press. (Ann. Bot.) (H.L.P. and R.J.G.)

65B. Phytohormones and the Growth of Apple Trees.

A technique for applying growth substances to whole plants by spraying has been investigated using plants of tomato and broad bean, and the results published (F20, F24). Some preliminary treatments of vigorous and dwarfing apple rootstocks Malling Nos. XII and IX with hetero-auxin by the spray method have shown differences in the response of these two types of rootstocks. Work is therefore being started with a view to (1) observing the response of different rootstocks and varieties to treatment with growth substances, and (2) estimating the normal hormone production of various rootstocks and varieties by a biological test. (H.L.P.)

65C. The Production of Galls on Apple Rootstocks by Treatment with Growth Substances.

In collaboration with Pathology (see V, Pathology, 70) experiments on the production of galls on apple rootstocks by synthetic growth substances have been started. During 1937 galls have been successfully produced using lanolin pastes of indolebutyric acid, and α-naphthalene acetic acid on three varieties of rootstocks of different vigour Malling Nos. II, VII and XVI. The galls thus produced closely corresponded in external appearance to the galls produced by inoculation with *Bacterium tumefaciens* itself. The growth of the trees of No. II was significantly decreased by the treatment, that of No. VII slightly increased, and that of No. XVI unaffected. See this Report, p. 187. (H.L.P. and R.V.H.)

PUBLICATIONS DURING THE YEAR.

Pearse, H. L. " The Effect of Phenylacetic Acid and Indolebutyric Acid on the Growth of Tomato Plants." Journ. Pom. and Hort. Sci. 1937, **14**, 365-75. (F20.)

Summary.

1. A method of applying phenylacetic and indolebutyric acid in the form of a spray to the aerial parts of tomato plants is described.

2. Epinasty of the leaves, swelling of the stems and petioles and initiation of roots on the stems were obtained by this method, i.e. results similar to those obtained by other

workers who applied these substances locally (dissolved in lanolin) or supplied them in aqueous solutions to the soil.

3. A daily application for one week of either phenylacetic or indolebutyric acids caused increase in height, and increase in length of the internodes and petioles as compared with control plants similarly sprayed with tap water. In addition, it induced differential responses in various parts of the plants ; with phenylacetic acid leaf and root growth was depressed, while stem and petiole growth was increased ; with indolebutyric acid leaf growth was depressed, and root, stem and petiole growth was increased.

4. Growth of the apical bud was gradually inhibited, indolebutyric acid acting rather more quickly than phenylacetic acid in this respect.

5. With phenylacetic acid the relative amount of leaf, as dry weight, in the treated plants as compared with the controls, remained practically constant after two and three weeks' treatment when sprayed with 0·1 per cent. solution. The relative amount of stem and petiole continued to increase. The amount of root began to increase again after one week, owing to the fact that new roots were initiated at the base of the stem.

6. The water content of the plants sprayed with phenylacetic acid and with indolebutyric acid was always greater than that of the controls.

Pearse, H. L. "Apple Trees in Water Culture." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 131-6. (F22.)

Sen, P. K. "Some observations on the Time of Development of the Fruit, Seed and Embryo in Apple." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 137-41. (F23.)

Pearse, H. L. "Effect of Hetero-auxin on the Growth of Broad Bean Plants in Water Culture." Nature, 1937, **140,** 26. (F24.)

Summary.

Supplying hetero-auxin to the culture solution at a concentration of 1 p.p.m. retarded the growth in length of the roots, although the total root weight was practically unaltered, while spraying approximately the same amount on the shoots decreased the weight of root growth without altering its form. The shoot growth was retarded by both treatments, but whereas spraying induced swelling of the stem and epinasty of the leaves, the plants receiving hetero-auxin in the culture solution did not exhibit any such symptoms.

Pearse, H. L. and Garner, R. J. "A Note on the use of alpha-Naphthalene Acetic Acid for rooting softwood cuttings of fruit tree stocks." Journ. Pom. and Hort. Sci. 1937, **15,** 248-51. (F25.)

Summary.

Preliminary tests on small numbers of softwood cuttings of certain plum and pear rootstocks and of black currant and fig indicate that immersion of the bases for twelve hours in 30-40 p.p.m. α-naphthalene acetic acid improved rooting markedly.

IV. BIOCHEMISTRY

MUTUAL INFLUENCE OF ROOTSTOCK AND SCION, Etc.

66. Elementary Analysis.

(i) Polarographic. No work has been possible.

(ii) Spectrographic. Dr. E. M. Case continued for three months the work dropped by Mr. A. L. Tackley when he took up a post elsewhere. (E.M.C.)

(iii) Chemical. Rapid chemical methods have been adapted to the estimation of minerals in solution in plant material (leafstalks) for the preliminary rapid diagnosis of mineral deficiency, the indications being followed up by injection (see below 68). (H.H.)

67. Organic Analysis.

Mr. J. K. Eaton was appointed to undertake this work. (W.A.R. and J.K.E.)

68. Plant Injection.

Distribution.

A paper covering the general field of plant injection is now ready for publication.

Leaf and other methods have now been worked out for most of the kinds of plants in which the Station is interested. (W.A.R.)

Dosage and Avoidance of Damage.

Further experience has been obtained in suiting the dosage to the size, rate of growth, variety, etc. of the material to be injected and to the rate of absorption. (B.F.G.L. and H.H.)

Diagnostic Value of Leaf Injection Methods.

Experiments on plants growing in sand under known deficiency conditions have thrown light on how best to use leaf injection methods for diagnosis. Results have been obtained with nitrogen, phosphorus, potassium, iron and boron. (H.H.)

Results of Injection.

(i) Artificial Manures. Responses have been obtained in the plantation to the experimental injection of compounds of nitrogen, phosphorus, potassium, and magnesium. (H.H. and B.F.G.L.)

(ii) Iron salts for chlorosis. In co-operation with the Advisory Officers in Commercial Fruit Growing to the Kent Education Committee, tests are being made in a number of commercial plantations, affected by severe or incipient chlorosis, of the practical value of injection of iron salts both alone and in conjunction with measures aiming at rendering the iron in the soil soluble by means of organic matter. (W.A.R. and B.F.G.L.)

(iii) The effects of nitrogenous and phosphatic compounds on the fruit. The effects in relation to keeping quality are being studied in co-operation with Dr. A. C. Hulme of the Ditton Laboratory, and in relation to resistance to fungus diseases in co-operation with Dr. A. S. Horne of the Imperial College. (B.F.G.L. and W.A.R.)

(iv) Nutrients and Disinfectants against Silver Leaf. (See V, Plant Pathology, Mycology and Bacteriology, 72). The conclusions drawn from past experiments have been put to a practical test, the results of which should begin to be seen in 1938. (W.A.R. and H.W.)

(v) Insecticides against Woolly Aphis (see VI, Entomology, 82).

(vi) Molybdenum compounds. In abeyance.

(vii) Biennial bearing. In abeyance.

(viii) Effect of Nutrient salts on Insect Pests. This work has been continued in co-operation with the Entomology Section. (B.F.G.L.)

(ix) Physiological Disorders (Bitter Pit, Water Core, Cork troubles, etc.). The apparent lessening of certain symptoms in fruit gathered in 1937 from trees injected with boric acid in 1936 is perhaps the first clear suggestion of the presence in this country of boron deficiency troubles which are serious overseas. (B.F.G.L., H.H. and W.A.R.)

(x) Effect of Nutrients on Apple Scab. There was insufficient Scab in 1937 to test the tentative conclusion drawn from the 1936 results. (B.F.G.L. and M.H.M.)

WOOLLY APHIS.

See VI, Entomology, 82.

ABSORPTION OF NUTRIENT SALTS BY ROOTS.

See III, Plant Physiology, 64 (*f*).

BACTERIAL DISEASES OF FRUIT TREES.

See V, Plant, Pathology, Mycology and Bacteriology, 74.

The trees mentioned in the last Annual Report will be injected and inoculated with the organism in 1938. (W.A.R. and H.W.)

INARCHING TO IMPROVE TREES ON POOR ROOTSTOCKS.

See I, Pomology, 1.

MULCHING.

No mulching experiment was done in 1937. (W.A.R.)

PUBLICATIONS DURING THE YEAR.

ROACH, W. A. "The Problems raised by the Woolly Aphis of the Apple. A Case for Team Research. VIII. Studies on Possible Causes of Immunity." Ann. Appl. Biol., February, 1937, **24**, 206-10. (K17.)

SUMMARY.

1. Immunity from Woolly Aphis attack does not appear to be explicable in terms of structure of the host.

2. Aphides were reared on artificial media prepared from the barks of immune and susceptible trees.

3. The development of the insects on the media corresponds to their development on living trees in that the number of young produced was smaller, and their life period was shorter, on the immune than on the susceptible.

4. The results suggest that the cause of immunity (or susceptibility) is carried by a chemical substance insoluble in alcohol and ether and only slightly soluble after prolonged boiling in water.

ROACH, W. A. "The Injection of Single Interveinal Areas of Leaves for Diagnosis of Mineral Deficiency." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 142-5. (K18.)

ROACH, W. A. "'Iron Shortage' Chlorosis in Apple Trees grown in Water Culture." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 146-9. (K19.)

ROACH, W. A. "Leaf-stalk Injection for the Diagnosis of Mineral Deficiency." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 150-2. (K20.)

ROACH, W. A. and LEVY, B. F. G. "'Iron Shortage' Chlorosis in the Plantation. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 153-9. (K21.)

ROACH, W. A. "The Injection of Individual Branches of a Tree Independently of each other." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 160-6. (K22.)

SRIVASTAVA, D. N. "The Injection of Individual Branches of a Spur-pruned Pear Tree." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 167-70. (K23.)

SEN, P. K. "The Injection of Individual Branches of a Tree which has not been Spur-pruned." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 171-3. (K24.)

ROACH, W. A. "The Injection of Whole Trees." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 174-9. (K25.)

HILL, H. "Functional Disorders of Apples on the Tree." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 180-2. (K26.)

LEVY, B. F. G. and ROACH, W. A. "Preliminary Injection Experiments on Bitter Pit in Apples." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 183-4. (K27.)

HULME, A. C., LEVY, B. F. G. and ROACH, W. A. "A Tree Injection Experiment on the Keeping Quality of Apples." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 185-6. (K28.)

V. PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

PATHOLOGY OF TOP FRUITS.

70. Crown-gall.

The work on the isolation of organisms from various hosts has been continued with the object of testing their parasitism. Large galls on raspberry plants have come under observation ; in some of these it was found that the growing point produced a terminal gall, instead of growing out to form a normal cane. (H.W.)

Another trial has been carried out during the year to test the value of an organic mercurial compound in controlling crown-gall on young nursery material of apple rootstocks. When the stocks were lifted for examination it was found that although there were fewer galls on the treated than on untreated stocks, the galled plants were so few (only 2 per cent. in those untreated) that the results were considered to be inconclusive. A further trial is being planned. (H.W. and R.J.G.)

The Etiology of Crown-gall on Apple Trees with special reference to the apparent Relative Susceptibility of Apple Stocks.

Experiment III (1935 *et seq.*), *Stocks Nos. I, II, VII and XVI.* (See Ann. Repts. for 1935 and 1936.) The second season's growth records were completed and the trees transferred from pots to the open ground. The growth of trees of Nos. VII and XVI stocks inoculated with *B. tumefaciens* was found to be significantly *greater* than that of the uninoculated (but otherwise exactly comparable) " control " trees.

Experiment IV (1937 *et seq.*), *Stocks Nos. II, VII and XVI.* Indications were obtained from the preceding experiment that the " take " of inoculations may bear relation to whether the tree is inoculated in or out of winter dormancy. In the present experiment therefore series of trees (planted January, 1937, in pots) were inoculated (*a*) in or near the dormant period and (*b*) in the full growing period. In addition to inoculations with the crown-gall organism inoculations on a parallel set of trees (by the same method) were made with lanolin pastes of certain synthetic growth promoting substances. The results to the end of the year are briefly as follows. (1) The relative susceptibility of the stocks to gall production as shown by previous experiments was confirmed. (2) Inoculations of stocks Nos. II and XVI with *B. tumefaciens* in June produced more galls than those made in April. (3) Large galls similar to crown-galls were readily induced by the inoculations with lanolin pastes of synthetic growth substances. (4) The growth of trees of stocks Nos. II, VII and XVI inoculated with *B. tumefaciens* was significantly greater than the otherwise comparable control trees. (5) The growth of trees of No. II stocks inoculated with " growth substances " was, conversely, significantly less than that of the control trees.

The above results are presented in more detail elsewhere in the present report. (See also III, Physiology.) (R.V.H. and H.L.P.)

71. Brown Rot.

Further observations were made during 1937 on plums taken from cold storage to ascertain the fungi chiefly responsible for the wastage. Again the chief fungus present proved to be *Sclerotinia fructigena*. The observations made during 1936 have been correlated with those of 1934 and the results published (C131). The fungi found on rotting plums taken from cold storage are generally *S. fructigena* and *S. laxa*, the former predominating ; fungi also partly responsible for the rotting but of less importance were *Botrytis cinerea*, *Mucor* sp. and *Penicillium* sp. (H.W. and A.C.P.)

For results of spraying trials against Brown Rot in Morello cherries, see under VII, Insecticides and Fungicides.

72. Silver Leaf.

(*a*) Further observations have been made on plum trees with Silver Leaf which had been injected with various nutritive and fungicidal substances to ascertain what effect such treatment has on the disease. (See IV, Biochemistry, 68.)
(W.A.R. and H.W.)

(*b*) Plum trees, inoculated with a fungus isolated from apple trees with a papery bark disease following grafting, have shown Silver Leaf and have produced fructifications of *Stereum purpureum*, thus offering further evidence that the papery bark condition is brought about by infection with the Silver Leaf fungus. (H.W.)

73. Influence of Stock on Scion.

In relation to disease, see VII, Insecticides and Fungicides, 97.

74. Bacterial Diseases of Fruit Trees.

Bacterial Canker of Plum Trees.

Field experiments and observations with the object of ascertaining the effect of soil conditions on the incidence and intensity of this disease are under way. Data of cultural and soil conditions in commercial plantations are being collected in an endeavour to find out what the conditions are which are conducive to susceptibility or resistance.
(H.W. and H.B.S.M.)

A new trial of trees, in sand cultures receiving various manurial treatments, was started in the spring of 1936 and the treatments continued throughout that season and 1937. In the autumn of 1937 the trees were inoculated with *Pseudomonas mors-prunorum* and the results will be recorded in 1938. (F.H.B., W.A.R. and H.W.)

The results obtained on plots of young plum trees receiving various fertilizers and combinations of fertilizers have been examined. No significant differences in the size of cankers on the plots was obtained with the possible exception of those plots receiving a dressing of lime ; on these plots the cankers, on the average, were larger than those on plots not receiving lime. (H.W. and R.J.G.)

Observations have been started on a plot of Victoria plum trees with stems of various varieties to obtain information on the incidence of Bacterial Canker in relation to time of pruning and time of spraying, and on the possibility of providing stems of resistant varieties on which to work Victoria. (M.H.M., H.B.S.M. and H.W.)

In 1936 an organism, suspected to be *Pseudomonas mors-prunorum*, the cause of Bacterial Canker in plum and cherry trees, was isolated from stem and leaf lesions on

almond and from a stem of the Purple-leaved Plum, and inoculation experiments were carried out to ascertain whether the organisms isolated from these ornamental shrubs could infect plum trees. Positive results were apparent in the summer of 1937, and the size of cankers was recorded. (See p. 198 of this Report.) (H.W.)

Bacteriosis of Cherry Trees.

Reports have been published during the year dealing with field observations on bacterial diseases in cherry (C126) and with the relative susceptibility of varieties of cherries (C127). The symptoms of bacteriosis in sweet cherries are stem, crutch, and branch cankers, shoot wilt, bud and spur blight, leaf spots and, occasionally, fruit spots ; these diseases on cherry are compared with similar diseases in plum ; measures for controlling them are discussed. (H.W. and N.H.G.)

Spraying Trials.

Spraying experiments on cherries on the Station are under way ; it has been found that bacterial cankers are fewer on trees sprayed in the autumn and again in spring than on unsprayed trees, but a really satisfactory method of control has not yet been evolved. (M.H.M., H.B.S.M. and H.W.)

Bacteriosis in Pear Trees.

In 1937 Bacterial Blossom Blight of pears was observed in several plantations in Kent ; in some of them much damage was caused. Again bacteria similar to those obtained previously from blighted blossoms were isolated and proved able to cause lesions on young pear fruits. Inoculations on pear flowers have, however, up to the present given negative results. (H.W.)

PATHOLOGY OF SMALL FRUITS.

75. Fungous Diseases and Non-parasitic Disorders of the Raspberry.

See special report on Raspberries under IX.

76. Raspberry Mosaic Disease.

See IX, Raspberries.

77. Loganberry Cane-spot, and

104. "Reversion" Disease of Blackberry and Loganberry.

See XI, Loganberries, Blackberries and Dewberries.

78-9. Strawberry Diseases.

See special report on Strawberries under X.

MISCELLANEOUS.

80A. Verticillium Wilt of Hops.

This investigation was continued in collaboration with Mr. B. S. Furneaux of the South-Eastern Agricultural College, Wye, and, as far as the very limited available time

permitted, further "water-table observation tubes" were installed at the two experimental centres referred to in the last Report, and the seasonal data from these experiments and from concurrent field observations further confirmed the close correlation between the economic severity of the disease, annual rainfall, and local soil water-disposal conditions. The disease appeared in three other localities in Kent during 1937.

In collaboration with Messrs. Whitbread & Co. a demonstration of the disease and the lines along which the problem of control is being studied was made during the tour of the British Institute of Brewing in September. For a summary of conclusions to date, see p. 257 of the present Report. (R.V.H. and B.S.F.)

80B. A Wilt of Shoots in Layer Beds.

Work has been continued on a wilt disease of shoots in layer rows of plum, cherry, peach, and apricot. The fungus associated with this disease is a species of *Cylindrocladium*. Cultures of species of this genus have been collected for comparison. When grown in pure culture the fungus isolated at East Malling resembles a species which has been isolated in America from strawberry and raspberry plants.

80C. Sooty Blotch.

As a result of the severe outbreaks of Sooty Blotch on apples and plums in 1936 treatments were tried for removing the blemishes, and the results were published in 1937 (C128, 130). It was shown that the blotches could be made inconspicuous by treating the fruit with a solution of bleaching powder (5 per cent.), and exposing it to the air for 10 minutes; the fruit is then washed and allowed to dry.

PUBLICATIONS DURING THE YEAR.

Wormald, H. "Bacteriosis of Stone Fruit Trees in Britain. VI. Field Observations on Bacteriosis of Sweet Cherry Trees." Journ. Pom. and Hort. Sci., 1937, **15**, 35-48. (C126.)

Summary.

1. The serious damage caused by bacterial infection in a number of commercial cherry orchards is described.

2. The symptoms of bacteriosis in sweet cherry trees are stem, crotch and branch cankers, shoot wilt, bud and spur blight, leaf spots, and, occasionally, fruit spots.

3. Certain varieties such as Bigarreau de Schrecken, Cluster Black Heart, Black Tartarian, Emperor Francis, Bradbourne Black and Black Eagle, have proved to be very commonly attacked. Frogmore and Governor Wood, in the observations recorded, have suffered less than other varieties.

4. The organism causing bacteriosis in sweet cherry trees in Britain are *Pseudomonas prunicola* and *P. mors-prunorum*.

5. A summary is given of the work on bacterial diseases of cherry trees abroad.

6. Cherry bacteriosis is compared with that on other species of *Prunus*.

7. Methods for controlling these bacterial diseases in cherry trees are discussed.

GRUBB, N. H. "Bacteriosis of Cherry Trees: Relative Susceptibility of Varieties at East Malling." Journ. Pom. and Hort. Sci., 1937, **15,** 25-34. (C127.)

SUMMARY.

Observations on the East Malling collection of cherry varieties have shown that:

1. Varieties differ widely in their susceptibility to Bacterial Canker.

2. There are several types of infection, of leaf, spur, branch and stem, and varieties differ in their relative susceptibility to these various types.

3. Whilst rootstocks may indirectly influence the susceptibility of the scion, they do not appear to influence it directly; susceptible scions on resistant rootstocks may be completely killed to the point of union, though the stock is entirely uninjured.

4. The reliability of the observations, and certain questions of nomenclature, are discussed, as is also the possibility that local conditions may influence the relative susceptibility of varieties.

WORMALD, H. and HARRIS, R. V. "Notes on Plant Diseases in 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 187-9. (C129.)

WORMALD, H. "Sooty Blotch of Apples and Plums." Journ. Min. Agric., 1937, **43,** 923-5; Kent Farmers Journ., 1936, **40,** 248; and E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 295-6. (C128.)

WORMALD, H. "The Sooty Blotch Disease of Apples and Plums." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 194-7. (C130.)

WORMALD, H. and PAINTER, A. C. "Further Observations on Brown Rot of Plums in Cold Storage." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 198-200. (C131.)

HARRIS, R. V. "Virus Diseases in Relation to Strawberry Cultivation in Great Britain —A Synopsis of Recent Experiments at East Malling." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 201-11. (C132.)

HARRIS, R. V. "Studies in Strawberry Virus Diseases. III. Transmission Experiments with 'Crinkle', 1935." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 212-21. (C133.)

WORMALD, H. "Bacterial Canker in Plum and Cherry Trees." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 297-300. (C134.)

WORMALD, H. "Leaf Blotch of Hawthorn." Gard. Chron., **102,** 47. July, 1937. (C136.)

SUMMARY.

Mention is made of outbreaks of Hawthorn Leaf Blotch, caused by *Sclerotinia Crataegi*, in the spring of 1937. The disease was first recorded for Britain in 1926, and since then it has been seen on several occasions. It is related to, but quite distinct from, the common Brown Rot fungi, *Sclerotinia fructigena* and *S. laxa*.

HARRIS, R. V. and HILDEBRAND, A. A. "An Investigation of Strawberry Virus Disease in Ontario." Canadian Journ. of Res., 1937, **15,** 252-80. (C138.)

SUMMARY.

Following identification in 1932 of the Yellow-edge virus disease in England on the Royal Sovereign variety, "normal" plants of this variety from a clone minutely rogued for Yellow-edge were used at St. Catharines as indicators in a further study of virus as relating to certain Ontario varieties. Observations in the field and greenhouse, confined largely to the varieties Parson's Beauty, Premier (Howard 17), Forward and Glen Mary, showed that symptoms, analogous to those of Yellow-edge in England and sufficiently defined to permit of diagnosis, were apparent only on Parson's Beauty and Forward and then only for a limited period early in the growing season. In the 1933-5 transmission experiments (by runner grafting), symptoms macroscopically indistinguishable from those of typical Yellow-edge-infected plants in England were induced on Royal Sovereign from the local varieties Glen Mary, Parson's Beauty and Premier, which possess markedly the symptomless-carrier capacity. Of special interest was the deterioration of Premier components in certain graft series, the evidence suggesting reciprocal infection between test and indicator plants.

Finally, parallel experiments at the East Malling Station in 1935-6 provided supplementary data as follows: (1) Of the two parent *Fragaria* species common to commercial varieties in North America and in England, *F. chiloensis* was found to be a symptomless-carrier of Yellow-edge with a high order of resistance, and *F. virginiana*, in complete contrast, exhibited symptoms with extreme readiness together with high susceptibility, thus providing some explanation of the observed wide range of varietal reaction to disease of the Yellow-edge type. (2) A large proportion of the clone of Royal Sovereign plants used as "normal" indicators in the recent series of experiments, was found to be infected with a distinct virus of the "Crinkle" type, thus providing explanation of an observed reciprocal reaction in certain series with the Premier variety.

VI. ENTOMOLOGY

81. Red Spider.

Fruit-tree Red Spider.

Methods are being investigated for sampling Red Spider population on the tree. (R.M.G.)

82. Woolly Aphis.

Resistant Seedlings.

Inoculation tests were carried out on 723 seedlings raised at the John Innes Horticultural Institution, Merton, and at East Malling. The season was unusually favourable to the aphis under glass and most of the susceptible seedlings were attacked very early, often without direct inoculation. (A.M.M. and R.M.G.)

Causes of "Immunity" of apple varieties to Woolly Aphis.

Attempts have been made to find a suitable nutrient medium to which chemically separated fractions of the apple bark may be added. The effect of individual substances on the insects may then be observed.

(R.M.G., W.A.R. and A.M.M.)

83. Chemically treated Corrugated Cardboard Bands.

A progress report on the work in 1936 has been published. (D128.) The experiments in 1937 were designed to show the effect of the concentration of chemical in the band. Three treatments were compared with untreated bands and with β-naphthol-treated bands which are at present on the market. A comparison was also made between two inch and four inch bands. One treatment was significantly better than untreated bands for weevils and another treatment was better for codling larvae. The effect of concentration of chemical was noticeable in two of the treatments. In both of these the weevils preferred the higher concentrations and the codling larvae the lower.

(A.M.M., R.M.G. and A.J.D.)

84. Tortrix Investigations.

Biology and Control of the Bramble Shoot Webber. (See 86B.)

85. A Study of the Vectors of "Reversion" of Black Currants.

This investigation is being held over until suitable material is available.

(A.M.M.)

86A. Mites.

Very little time has been devoted to the study of gall mites, but a number of species received from Canada and New Zealand have been determined. The species from New Zealand proved to be a new one, and a systematic description has been published. (D129.) (A.M.M.)

86B. The Insect and Allied Fauna of Rubus.

Lepidoptera.

The life-cycle of the Bramble Shoot Webber (*Notocelia uddmanniana* L.) has been studied for one year. Certain phases need confirmation, and control measures are being investigated. A comprehensive list of other species of Lepidoptera which occur on Rubus is being obtained and will be completed shortly. (G.H.L.D.)

Aphididae.

No less than seven species of Aphides have been identified as definitely associated with Rubus. Three of these appear to have no alternative host; one migrates to a summer host plant, and the others are polyphagous. The life-histories and ecology of the more important species are being studied. (G.H.L.D.)

Coleoptera.

Damage due to various species of Coleoptera (excluding the Raspberry Beetle) has been observed. So far none has been noted to cause serious damage, but a small weevil, *Rhynchites germanicus* Hb., is of widespread occurrence, and damages the young canes by girdling them. (G.H.L.D.)

87-91.

See joint reports on Raspberries under IX, and Strawberries under X.

PUBLICATIONS DURING THE YEAR.

Greenslade, R. M. "The Problems raised by the Woolly Aphis of the Apple—A Case for Team Research. IV. The Control of Woolly Aphis." Ann. Appl. Biol., 1937, **24,** 184-7. (D124.)

Summary.

The distribution of *Eriosoma lanigerum* (Hausmann) and the type of damage caused by it are mentioned. The reasons for the difficulty of controlling this insect are set out and the use of spraying, dusting, hand painting, trapping, fumigation, tree injection and biological control as methods of combating it are discussed.

Massee, A. M. "The Problems raised by the Woolly Aphis of the Apple—A Case for Team Research. VI. Entomological Technique." Ann. Appl. Biol., 1937, **24,** 195-8. (D125.)

Summary.

A brief account is given of the methods used for testing apple stocks and seedlings for their resistance to Woolly Aphis from 1921 up to the present time.

By making certain modifications in methods of inoculating seedlings from time to time the methods now adopted are carried on each year as a matter of routine.

In 1925 about 100 seedlings could be tested in one season. At the present time approximately 1,000 seedlings can be tested per annum.

Massee, A. M. "Notes on Some Interesting Mites and Insects observed on Fruit Trees in 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 222-8. (D126.)

MASSEE, A. M. "Studies on the Transmission of the Strawberry Virus 'Yellow-edge' Disease by Insects. III. Aphid Transmission Experiments and Period of Infectability." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 229-31. (D127.)

MASSEE, A. M., GREENSLADE, R. M. and BRAIR, J. H. "Studies of Impregnation of Tree Banding Materials. III. Apple Blossom Weevil and Codling Moth Experiments in 1936. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 232-9. (D128.)

MASSEE, A. M. "An Eriophyid Mite injurious to Tomato." Bull. Ento. Res., 1937, **28**, 3, 403. (D129.)

SUMMARY.

A systematic description is given of the Eriophyid mite, *Phyllocoptes lycopersici* Massee.

The mite causes silvering and curling of the leaves of the tomato plant.

It occurs in Australia and New Zealand and is known as the "Tomato Rosette disease and Fruit Sterility".

MASSEE, A. M. "A Further Record of *Anthicus tobias* Mars." Ento. Mo. Mag., 1937, **73**, 191. (D130.)

SUMMARY.

The Heteromerus beetle, *Anthicus tobias* Mars. which was recently reported as an addition to the British list has been found in great profusion in the East Malling district.

MASSEE, A. M. "Nuts." Min. Agric. Bull. No. 106, 1937, pp. 12-15 and 34.

SUMMARY.

A brief account is given of the insects and mites which attack nuts and walnuts. Mention is made of life-cycles and methods of control.

MASSEE, A. M. "The Pests of Fruit and Hops." Crosby Lockwood & Son Ltd., London, 1937, pp. 294. Pl. 27. 15s.

SUMMARY.

The volume is divided into the following chapters: 1. Apple. 2. Cherry. 3. Currant: Red, White and Black. 4. Gooseberry. 5. Loganberry, Blackberry, Himalaya Berry and Phenomenal Berry. 6. Nut: Cob, Filbert and Walnut. 7. Peach, Apricot and Nectarine. 8. Pear. 9. Plum and Damson. 10. Raspberry. 11. Strawberry. 12. Hop. 13. Beneficial and Harmless Insects. 14. Insecticides. 15. Spraying Equipment and Methods. This last chapter is written by Mr. J. Turnbull. Foreword by Mr. J. C. F. Fryer and plates by Mr. R. M. Greenslade.

VII. INSECTICIDES AND FUNGICIDES

LABORATORY INVESTIGATIONS.

93, 98, 99, 100. Insecticides.

Methods of Testing.

The investigation of methods of testing insecticides has been continued ; a description of the methods evolved for testing ovicides has been published (Q9) and a summary appears on page 88. (W.S.)

Tests of Ovicides.

A further season's work on the toxic properties of tar and petroleum distillates has made possible a tentative correlation of properties. The inclusion of a vertical retort tar distillate has completed a range of hydrocarbon oils from a wholly aromatic tar oil to an aliphatic petroleum. Special attention has been paid to the connection between toxicity on the one hand and boiling range and dimethyl sulphate solubility on the other. The Fuel Research Station, Greenwich, and Messrs The Gas Light and Coke Co. have greatly assisted the progress of the work by providing samples of the various types of tar distillate.

Of the many organic substances examined normal dodecyl thiocyanate, β-butoxy-β′-thiocyano-diethyl ether, 3 : 5-dinitro-*o*-cresol and nicotine have shown most promise as ovicides and have been included in field trials. (H.S. and W.S.)

Physiological Aspects.

The co-operation of the Department of Entomology of the Imperial College of Science has been secured with a view to the investigation of the physiological action of insecticides.

95, 100. Fungicides.

Methods of Testing.

A full report has recently been published (Q8) and a summary is given below. (H.B.S.M. and M.H.M.)

Tests of Fungicides.

These have been in abeyance since the completion of the work recorded in the above report. (M.H.M.)

FIELD INVESTIGATIONS. I. MODIFICATION OF ROUTINE CONTROL MEASURES.

94. Influence of Supplements on Retention of Spray Residues.

A small scale field spraying trial was carried out to ascertain the effect on the deposition and retention of arsenical residue of the addition of oil emulsion, lime-sulphur and a wetter to a late June spray of arsenate of lead. Chemical analyses were carried out on samples of leaves and fruits picked at appropriate intervals after spraying. (See pp. 219-222.) (H.S. and W.S.)

96A. Insecticide-Fungicide Programme for Cox's Orange Pippin.

The results obtained in 1936 have been published as a separate report. (Q5.)

Scab infection was not particularly severe in 1937 and four applications of 1 per cent. lime-sulphur, two pre-blossom and two post-blossom, gave very good control which was not improved by the inclusion of a spreader. The spray without spreader caused more injury, shown as leaf-burn, defoliation, and fruit drop, than that with spreader, although this is probably connected with the amount of spray retained on the foliage and fruit in each case.

Lime-sulphur at 2½ per cent. pre-blossom, applied only to " buffer " trees, was not significantly more fungicidal than at 1 per cent., although admittedly there was little scope for improvement in this experiment. The stronger spray caused, however, more marginal burning of the rosette leaves than the weaker. (M.H.M.)

96B. Spreader Trials—Apple Scab.

The trial of various spreaders on young trees of Worcester Pearmain, Edward VII, Allington Pippin, and Newton Wonder was not continued. The only spreader trial carried out was that reported under 96A, above. An account of the work on spreaders during the past few years will be written up for publication in due course. (M.H.M.)

96, 100. Mitigation of Spray-Damage.

By addition of Ferrous Sulphate.

Confirmation of the results obtained in 1936 on Cox's Orange Pippin and Worcester Pearmain on No. II stock was forthcoming in 1937, when lime-sulphur was used at 1 per cent. post-blossom instead of at 1-60 as hitherto. The inclusion of ferrous sulphate reduced the amount of foliage injury on Cox's resulting from post-blossom applications of lime-sulphur with or without lead arsenate (in paste, powder or colloidal form) but failed to prevent severe fruit-drop on Cox's and Worcester. Leaf-burn and defoliation were absent in Worcester with all treatments. Further evidence was obtained that lime-sulphur with arsenate caused more injury than lime-sulphur alone ; there was little difference in effect between the various forms of lead arsenate, the powder form being, perhaps, slightly more injurious than the others.

This trial is now completed and a full report will be published in due course. (M.H.M.)

By addition of Cotton-seed Oil.

Evidence was obtained under 96 (Fungicide Trials) that the addition of cotton-seed oil at 0·75 per cent. to weak Bordeaux mixture (1-1½-100) prevented foliage injury to Allington Pippin, Worcester Pearmain and Newton Wonder, but increased severe fruit-russet. Scab-control was improved by the use of the oil. (M.H.M.)

By reduction of Spray-Concentration.

Results have been obtained from two sources reported under 96A and 96 (Fungicide Trials). Confirmation was obtained that lime-sulphur at 1 per cent. pre-blossom was safer than at 2½ per cent. and, in association with post-blossom applications, scarcely less fungicidal during the limited pre-blossom period. Weak Bordeaux mixture (1-1½-100), however, applied twice before and twice after blossom, caused very severe injury to Allington Pippin and Worcester Pearmain, yet failed to give adequate control of Apple Scab. A colloidal copper preparation at equivalent copper concentration caused even more severe injury than the Bordeaux mixture. (M.H.M.)

96. Effect of Sprays on Apple Blossom.

This is being studied in relation to the control of biennial bearing by blossom sterilization (see I, Pomology, 13, and III, Plant Physiology, 64 (*h*), Biennial Bearing) and to the control of Apple Scab. On Cox's Orange Pippin, lime-sulphur at 3 per cent. in full bloom proved fatal to most blossoms but at 1 per cent. it had a moderate thinning effect. Ferric chloride at 1 per cent. and at 0·75 per cent. was much too drastic; it burnt the foliage as well as the blossom trusses. Bordeaux mixture at 8-12-100 and at 4-6-100 sterilized most blossoms and burnt the rosette leaves; moreover, any fruits that reached maturity were severely russeted. The effect of these sprays on Scab-control was inconclusive in the absence of infection. (M.H.M.)

FIELD INVESTIGATIONS. II. TESTS OF NEW SPRAY MATERIALS.

94, 99. Insecticide Trials.

Winter Washes.

Comparable fractions of the several types of tar oil under investigation were tested in a preliminary field spraying trial against the eggs of the Leaf Curling Plum Aphis (*Anuraphis padi*). The results agreed with the laboratory findings and now await confirmation by further field trials.

Normal dodecyl thiocyanate and the closely related secondary compound were tested (at 0·3 per cent.) in a 5 per cent. oil emulsion against *A. padi* eggs. The results bore out the conclusions already drawn from laboratory tests that the straight chain compound is a much more potent ovicide than the branched chain derivative. Under comparable conditions, however, nicotine (at 0·05 per cent.) proved as toxic as the normal thiocyanate. (H.S. and W.S.)

Summer Washes.

Preparations of β-butoxy-β′-thiocyano-diethyl ether and of a dodecyl thiocyanate were tested. At a concentration of 0·05 per cent. of the active ingredient they were ineffective against the larvae of the Apple Sawfly (*Hoplocampa testudinea*). The former (at 0·1 per cent. and 0·2 per cent. of active ingredient) also failed to control the larvae of the Raspberry Beetle (*Byturus tomentosus*), but caused injury to the tips of young canes of raspberry.

Thiodiphenylamine (at 0·1 per cent.) was only partially successful in controlling larvae of Raspberry Beetle and of Plum Sawfly (*Hoplocampa flava*). (W.S.)

96. Fungicide Trials.

A full report on the 1936 investigations has been published (Q4). In 1937, further tests were made on Allington Pippin, Worcester Pearmain and Newton Wonder apples. Sprays were applied twice before and twice after blossom. The principal results (see also pp. 229-235) were: (*a*) The distinct promise shown by tetramethylthiuram disulphide and by a colloidal sulphur preparation, each applied post-blossom after lime-sulphur pre-blossom, against Apple Scab. (*b*) The failure of weak copper fungicides, as Bordeaux mixture and as a colloidal copper preparation, to prove safe to use and to give adequate Scab-control. (*c*) The value of cotton-seed oil as an addendum to weak Bordeaux mixture in mitigating foliage-injury and increasing the fungicidal properties of the spray, which, however, caused severe fruit-russeting. Unsprayed control trees were heavily infected by Scab. (M.H.M.)

FIELD INVESTIGATIONS. III. BIOLOGY AND CONTROL OF SPECIFIC PESTS AND DISEASES.

92, 94. Codling Moth.

Further experience has confirmed the value of spraying for this pest with lead arsenate in late June. (W.S.)

94. Plum Sawfly.

Field trials carried out on the Research Station's farm and on outside farms showed that this pest can be adequately controlled by spraying *once* with Derris and soap and that considerable latitude is permissible in timing the spray application. Some evidence was obtained that lower concentrations of Derris than the 0·2 per cent. normally recommended may prove satisfactory. (W.S.)

94. Red Spider.

The late summer attacks of Red Spider that have been observed in recent years, even on trees previously sprayed with winter petroleum emulsion, are apparently due largely to the influx of mites from neighbouring trees. The manner in which these mites are dispersed is now being investigated.

In a field spraying trial, designed to compare lime-sulphur and Derris and to determine to what extent the performance of an acaricide can be improved by the addition of wetters, the Spider infestation proved inadequate to enable conclusive results to be obtained. (W.S.)

96. Brown Rot in Morello Cherries.

The weather during blossom-time was highly favourable to epidemic infection, which progressed rapidly. The results given by tar-oil wash applied in the dormant period were partially inconclusive on account of an uncontrolled source of infection on unsprayed plums nearby. Tar oil at 10 per cent. failed to show any beneficial effect as this treatment was applied nearest to the infected plums; at 5 per cent., however, it showed some control. Each treatment had a marked cauterizing effect on the brown-rot pustules as in 1936, when very good control of the disease was obtained. The removal of sources of infection by the cutting-out of dead, pustule-bearing shoots was also very beneficial.

Bordeaux mixture (6-9-100) and lime-sulphur (2 per cent.) each gave very good control when applied just before blossom. The addition of a spreader did not improve the control. Two lime-sulphur sprays pre-blossom gave rather better control than one, but scarcely sufficient to justify the extra spraying. Bordeaux mixture appears, on the whole, to be safer than lime-sulphur.

This disease should be readily controlled on Morellos by rigorous cutting-out of infected shoots, together with an application of tar oil in the dormant period and Bordeaux mixture just pre-blossom. (M.H.M.)

96. Bacterial "Shot-hole" and Canker in Stone Fruits.

Considerable reduction in the incidence of cankers and of "bud-infections" resulted from the application to Bigarreau de Schrecken cherry of Bordeaux mixture in both autumn (10-15-100) and spring (6-9-100). Application in autumn only or in spring only was approximately half as effective as when the two were combined. Two applications at either or both periods were not significantly more beneficial than one.

Some influence of rootstock on the degree of infection in the scion was noted, though this was not clearly defined on account of the rather small units of trees on each stock.

A spraying trial on young, double-worked Victoria plum trees showed that Bordeaux mixture (6-9-100) applied at the end of May was not safe on the foliage, for much more " shot-hole " was caused by it than by the bacterium. Up to the present, few data are available on the incidence of canker on these plum trees.

(H.B.S.M. and M.H.M.)

97. Apple Scab.

Infection was not severe enough to show appreciable differences in the degree of Scab-infection occurring on two series of Bramley's Seedling trees under grass manured with 10 cwt. or 5 cwt. nitro-chalk per acre. Similar series of cultivated Bramley's receiving sulphate of potash with or without sulphate of ammonia were also lightly infected and the results are inconclusive. (M.H.M.)

Mention of the injection of certain nutrient solutions into Bramley trees for its effect on the incidence of Scab will be found under IV, Biochemistry, 68 (x) Results of Injection. (B.F.G.L. and M.H.M.)

97a. Branch-Blister Disease.

This is not nearly as frequently met with as it was a few years ago when there was shortage of moisture in several parts of the country. Pot experiments carried out in Essex in collaboration with the County authorities suggest that the incidence of Branch-Blister on Cox's is a function of growth. Trees that made little or no initial growth after potting, owing to the withholding of moisture, developed less blister than those that grew freely at first and were then subjected to drought conditions. A further pot experiment has been initiated in which soil moisture records will be obtained and the influence of potash dressings on the incidence of Blister will be studied. It seems highly probable that the disease is of physiological and not mycological origin, and that the fungus *Coniothecium* sp., associated with the blisters, is only secondary.

(M.H.M.)

96. Loganberry Cane-spot.

The spraying programme carried out in 1936 was repeated. Reference to the results will be found under XI, Loganberries, Blackberries and Dewberries, 77b.

(A.B.B., R.V.H. and M.H.M.)

PUBLICATIONS DURING THE YEAR.

Shaw, H. " Spray Residue Investigations. I. Determinations of Arsenic on Pears and Apples and of Copper on Loganberries." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 240-5. (Q1.)

Shaw, H. and Steer, W. " Investigations on the Preparation of Field-made Winter Petroleum Oil Sprays." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 246-9. (Q2.)

Steer, W. " Observations on Codling Moth (*Cydia pomonella* L.) in 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 250-8. (Q3.)

MOORE, M. H., MONTGOMERY, H. B. S. and SHAW, H. "Field Trials in 1936 of the Fungicidal and Phytocidal Properties of Certain New Chemical Preparations. I. Fungicidal Properties. II. Preliminary Phytocide Tests." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 259-66. (Q4.)

MOORE, M. H. and MONTGOMERY, H. B. S. "A Field Spraying Trial of Combined Fungicide-Insecticide Sprays in 1936." With an Appendix by W. Steer. E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 267-75. (Q5.)

MOORE, M. H. "Notes on the Control of Strawberry Mildew (*Sphaerotheca humuli*)." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 276-9. (Q6.)

STEER, W. "The Control of Codling Moth—a suggested spray programme." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 302. (Q7.)

MONTGOMERY, H. B. S. and MOORE, M. H. "A Laboratory Method for testing the Toxicity of Protective Fungicides." Journ. Pom. and Hort. Sci., 1938, **15,** 253-66. (Q8.)

SUMMARY.

1. The literature relating to laboratory methods for testing protective fungicides is reviewed.

2. The following method has been devised and tested: With a fine-bore pipette, quantities of 0·015 c.c. each of the liquid fungicide are spread uniformly over circular areas, each 15 mm. in diameter, delimited on glass slides. When the liquid has evaporated and the deposit is dry, 0·04 c.c. of a suspension in water of washed conidia from a pure culture of *Venturia inaequalis* is applied in a similar manner, and the slides are then stored in a saturated atmosphere at 20° C. At intervals counts of germination are made. When desired the spray-deposit is washed with water before the conidia-suspension is applied.

3. A method of growing *Venturia inaequalis* in pure culture for the production of conidia is detailed, as well as one for freeing the conidia-suspension from nutriment by centrifuging.

4. A method is presented for rapidly assessing the results of treatments by classifying the mass appearance of conidia-germination into five categories.

5. The results of a number of tests with copper- and sulphur-containing inorganic substances, and also with certain organic compounds, are tabulated and discussed. Amongst the last-named, tetramethylthiuram disulphide was found to be very highly fungicidal.

W. STEER. "Laboratory Methods for the Biological Testing of Insecticides." Journ. Pom. and Hort. Sci., 1938, **15,** 338-55. (Q9.)

SUMMARY.

Standardized methods of conducting biological tests with suitable insect species as indicators are indispensable for the rapid sorting of new and potential insecticides and for the correlation of toxicity and chemical constitution. Careful attention to details of rearing and handling is necessary to eliminate all but inherent sources of variation in the insects used.

For testing ovicides the eggs of *Orgyia antiqua* L., *Operophtera brumata* L., *Aphis pomi* de G. and, to a lesser extent, *Oligonychus ulmi* Koch, are used.

O. antiqua is bred in large numbers and is useful for tests of contact and stomach poisons in addition to ovicides. After insecticidal treatment the eggs are incubated at 21° C. to accelerate hatching and to get early results.

Females of *O. brumata* are collected in orchards and induced to lay eggs on twigs in special cages. The twigs are then dipped in the insecticide and the result assessed from subsequent counts of hatched and unhatched eggs. Eggs laid on muslin can also be utilized if the testing procedure is suitably modified.

Shoots bearing eggs of *A. pomi* are collected from apple rootstock stool-beds and treated by an adaptation of the Kearns and Martin method.

O. ulmi eggs can be used but are not altogether satisfactory.

Spray materials that show sufficient promise in laboratory tests are applied to branches of fruit trees to ascertain whether they are safe to use. If satisfactory, they then undergo successive stages of field trial.

VIII. EXTERNAL CONTACTS

101. Enquiries and Visitors.

The number of letters written in the course of the year in answer to enquiries amounted to 1,713 and in addition there has been an increasing number of telephone enquiries. Visitors to the Station numbered 2,817, including 200 visitors from overseas and forty-nine organized parties.

(N.B.B., H.C.C., H.B.S.M. and the staff in general.)

102. Conferences, Demonstrations, Lectures and Exhibits.

Three conferences and three open days have been held and eighteen lectures given by members of the staff. Nine educational exhibits have been staged at various shows. For further details of External Contacts see the Supplementary Annual Report (twenty-fifth year), General Development and Activities. (Misc. Publ. A23.)

PUBLICATIONS DURING THE YEAR.

Bagenal, N. B. "Some Notes on the Work at East Malling Research Station." Rep. and Journ. of the Women's Farm and Garden Assocn., 1936-7. 1937, 34-7. (E120.)

Summary.

A short popular account of the work at East Malling Research Station. The concerted nature of the experiments is illustrated by an account of the research on rootstock influence, and a short account of the activities of most of the sections is also given.

Montgomery, H. B. S. "Strawberry Problems at East Malling Research Station." Guildford and District Hort. Soc. Monthly Journ., 1937, **13,** 6, 13-16. (Esf.30.)

Summary.

A popular account of the work done on Strawberry Problems at East Malling Research Station. The aspects which are briefly dealt with include propagation, virus elimination, mite control and the factors concerned in establishing a healthy strawberry plantation.

Montgomery, H. B. S. "Mosaic Disease of Raspberries at East Malling Research Station." Guildford and District Hort. Soc. Monthly Journ., 1937, **13,** 7, 1-3. (C137.)

Summary.

An account is given of the nature of mosaic disease of raspberries, and the symptoms are briefly described. Emphasis is laid on the importance of using mosaic-free canes for planting up fruiting plantations, and the special cane-nurseries are referred to.

Montgomery, H. B. S. "'Reversion' in Black Currants." Guildford and District Hort. Soc. Monthly Journ., 1937, **13,** 8, 15-16. (Esf.31.)

Summary.

The investigations at East Malling to determine the cause of reversion in black currants are briefly recounted. The chief points to look for in diagnosing reversion are indicated and directions are given for the establishment and maintenance of healthy plantations of black currants by means of healthy planting material and yearly roguing.

Montgomery, H. B. S. "Notes from East Malling Research Station.—Bacterial Canker in Plum and Cherry Trees." Guildford and District Hort. Soc. Monthly Journ., 1937, **13,** 9, 13-16. (C139.)

Summary.

A short popular description of Bacterial canker in plum and cherry trees summarizing the results of the experiments at East Malling on the cause and control of this disease. Directions are also given for the preparation of Bordeaux mixture.

Bagenal, N. B. "On the Choice of Rootstocks for Apples." Guildford and District Hort. Soc. Monthly Journ., 1937, **13,** 11, 9-11. (E130.)

Summary.

A short popular account for amateurs of the rootstocks available at the present time for apple trees in gardens.

IX. RASPBERRIES

(Combined Pomological and Pathological Investigations.)

42. Variety Trials.

Eight fresh varieties were received during the past year. One further lot, sent in under a well-known name, proved to be a mixture of four varieties, none at all resembling the variety named. Whilst we are sure that in this case there was no attempt to mislead, the mistake being due only to a lack of knowledge of the true variety, it is clear that care is still needed in obtaining even well-known varieties true to name.

The seven American seedlings (of Lloyd George × Newman parentage) recently received bore in 1937 their second good crop of fruit. None appears to show any particular promise in either quantity or quality of fruit. All but one have, however, remained free from mosaic symptoms. If they prove eventually to be highly resistant to infection, they may at least be useful for future breeding work.

Newburgh again bore a good crop of excellent fruit ; it is still by far the most promising American variety in the East Malling collection. It has not yet shown any mosaic symptoms. (N.H.G.)

47. Breeding.

The seed of the nine families sown in 1936 germinated poorly, and two months later than usual, perhaps owing to the very mild winter, 1936-7. Seedlings of eight of them were planted out in 1937. A large majority of the seedlings in the ninth family, raised by selfing a seedling of mosaic-resistant pollen parentage (Preussen ♀ × Baumforth A ♂) showed what appeared to be pronounced mosaic symptoms at an early stage in the seed pan ; they were not planted out, but several were potted up for further observation.

The seedlings planted out in 1936 bore a small amount of fruit, but seldom enough to indicate their value. One family, however, gave an unexpectedly disappointing result ; the fruit of almost every plant that fruited turned exceptionally dark coloured when fully ripe, and this although both parents (two specially selected seedlings) were free from this fault. The fault is clearly the product of more than one factor.

Ten seedlings selected from later families than those represented in the combined seedling and manurial trial (see 59 below) are being planted in propagation beds this winter. (N.H.G.)

50. Propagation.

In addition to Norfolk Giant and the New Zealand " Hornet ", mentioned in last year's Report, Newburgh has now been added to the mosaic-free propagation plot. (N.H.G. and R.V.H.)

55. Pruning and Thinning.

It is not proposed at present to make a fresh start with this work. (N.H.G.)

59. Manuring.

The third year of the combined seedling and manurial trial, in which the first heavy crop was produced, shows for the first time a significant difference between the

effects of the manurial treatments. Plots which received 2½ cwt. of sulphate of potash each year (three times to date) bore significantly more weight of fruit than those which received the same amount in alternate years (twice to date) ; and both bore significantly more than those which received, in the first year only, either the same amount, or 10 cwt. per acre.

All the seedlings continued to grow well, and were again more vigorous than either Lloyd George or MacLaren's Prolific. Each of the two best seedlings bore significantly more weight of fruit than any one of the others, which in turn bore significantly more than either named variety.

Striking differences in fruit size, and considerable differences in fruit colour and firmness, were found.

Records were taken of cane-spot infection on the fruit from this trial ; the results are fully dealt with under 75A. (W.A.B. and N.H.G.)

75A. Raspberry Cane-spot (*Elsinoë veneta*).

During 1937 a severe direct infection of fruit-laterals and berries was recorded on many varieties. A grading for cane-spot infection of the fruit from a single picking (12th July) of the above Manurial Trial (Sect. 59) showed a relative varietal susceptibility varying from a mean of 12 per cent. infected fruits for one " seedling variety " to 20 per cent. for Lloyd George. Infection reached as high as 80 per cent. in certain samples of the latter variety. No routine measures for the control of this disease have been applied to this trial.

Regarding possible effects of manuring on the disease incidence, there were indications that the attack was less severe under one of the treatments. This result will be followed up as opportunity arises. (R.V.H. and W.A.B.)

75B. Non-parasitic Disorders.

On the basis of a striking correlation between local severe outbreaks of these disorders (variously referred to in previous reports as " die-back ", " black root-rot ", " crown rot " and " dwarf lateral scorch ") and mild mean-temperatures in the preceding winters, the following experiment was made. Comparable series of two-year-old stools in pots of the varieties Lloyd George and Baumforth's Seedling B were placed during the months of December, January and February, (A) in a cold-storage chamber at 31·5° F.* and (B) in a greenhouse maintained at a temperature fluctuating between 40° and 55° F. Afterwards both series were brought together in the latter greenhouse and were carried through to cropping. Detailed surveys of each cane at short intervals during the growing season yielded the following results for the Lloyd George variety :

(i) Considerable die-back of complete stools, and of individual fruiting canes, occurred at all stages from bud-break to the cropping period in series B, but was entirely absent in series A.

(ii) The mean percentage of normal fruit-bearing laterals on stools in series A was significantly higher than that in series B.

(iii) The scorching and distortion of leaves (characteristic of " dwarf lateral scorch ") and " pseudo-mosaic " symptoms occurred widely in series B, but were absent in series A.

* The writer is indebted to Dr. C. West of Ditton Laboratory for facilities kindly provided

(iv) The crop yield of series A (by weight and number of berries) was higher than that of series B.

(v) As a result of the check to the fruiting canes the growth of new cane in series B was significantly higher than in series A.

In the case of Baumforth's Seedling B no significant differences between the two series in any of the above respects was recorded. Conversely there was a tendency to low-temperature injury in series A. (R.V.H.)

76. Raspberry Virus Disease.

Transmission Experiments in Symptom Analysis.

Reference was made in the Report for 1936 (p. 79) to the unreliability of all extant methods of cane-grafting. In 1937 a new method (by cane inarching) was attempted and has proved completely successful. In conjunction with parallel experiments with virus diseases of other Rubus species (see XI, 104) 43 out of 45 grafts attempted by this method were successful, including the following combinations :

(i) European to American Red Raspberry.

(ii) European and American Red Raspberry to American Black Raspberry.

(iii) Logan and Phenomenal Berry.

(iv) Blackberry and Youngberry to Phenomenal Berry and to European Red Raspberry.

These experiments are yielding positive results, and the plants are being retained for further observations. (R.V.H.)

Experiments in Commercial Control.

Routine inspections and " roguings " have been carried out on (i) the " mosaic-free " cane-propagating plots at the Research Station and (ii) (in collaboration with the County Horticultural Staffs) the extension experimental cane-nurseries in Kent and Sussex. These have yielded satisfactory results.

Consignments of mosaic-free cane have again been distributed to growers for propagation purposes. (N.H.G. and R.V.H.)

88. Raspberry Insects.

The species of Aphididae associated with the raspberry have now been identified as a preliminary step to a large-scale inoculation experiment with the various aphids for the determination of the vectors of mosaic.

Attempts to transmit mosaic diseases by means of an aphid were made again in 1937 and the results, though inconclusive, warrant a continuation of the experiments. (G.H.L.D. and A.M.M.)

X. STRAWBERRIES

(*Combined Pomological and Pathological Investigations.*)

44. Classification, Nomenclature and Variety Trials.

Clonal races of important varieties and certain selected strains have been kept under observation. This work will be limited in scope until new virus-tested clones are available. (W.S.R.)

48. Breeding.

A number of families were raised during the past year from crosses between *Fragaria chiloensis*, *virginiana* and *vesca*. The cultivated European strawberry varieties are said to have originated from a hybrid between *F. chiloensis* and *F. virginiana* and in repeating the cross, it is hoped ultimately to raise new varieties with characters facilitating the recognition of virus infected plants. *F. vesca* was used because it not only shows symptoms of virus disease more readily than any of the cultivated hybrids, but also because it has been shown to be immune, under certain conditions, to infestation by the aphis vector. A large number of seedlings have been raised from these crosses, some of which will be used for intensive work on the artificial transmission of virus disease, and the rest will be planted out in the field for a careful study, over several years, of their possibilities as new varieties of value.

Several families of seedlings, raised at the John Innes Horticultural Institution, from crosses between Royal Sovereign, Cessnock and Marcienfelde have been under trial here. They fruited for the first time during the past season and thirteen were selected as being worthy of further trial. Small units have been propagated from these plants and are being planted out for a small comparative test of their commercial value. (H.M.T.)

52. Propagation.

The establishment of "virus-free" clones.

On account of the very large demand for our selected clonal Royal Sovereign, an area of $4\frac{1}{4}$ acres of maiden plants, originally intended for fruiting, was converted into an isolated block runner bed. It was gratifying to find that the plants removed on account of virus symptoms numbered only 0·75 per cent. Runners were also raised from some of the two-year-old plants of last year's runner beds. These parent plants were also allowed to crop in order to check their enormous vigour sufficiently to make roguing easy. This considerably reduced the runner formation.

Preliminary field tests for freedom from virus disease of clones of Royal Sovereign and other varieties newly selected in 1936 were carried out during 1937 by means of the indicator *F. vesca*. Normal plants of this species were planted (in the runner bed) adjacent to the plant under propagation and the two plants were runner-grafted together. On the basis of this test re-selections have been made which will be subjected to further tests in an aphis-proof greenhouse in 1938. (See 78.)

(W.S.R. and R.V.H.)

Individual Plant Studies of Clonal Families.

The full records of the vigour, cropping and health of about 2,500 individual Royal Sovereign strawberry plants, from the time of their formation as runners to the end of their commercial life, show the following results. (1) Any healthy runner, provided it becomes established, has the potentiality of becoming a vigorous fruitful plant. (2) The earliest formed runners were the largest. (3) The largest runners showed least mortality after planting out, and greatest crop potentialities in the season following planting. All plants were deblossomed in this season. (4) In the second and subsequent seasons there were no important differences in vigour or crop between plants initially large or small, early or late, or of whatever position on the stolon. (5) There is no need to limit the number of runners per parent in order to get satisfactory results. Under good conditions, very small plants can be successfully established, but for commercial purposes plants weighing less than about seven washed runners to the ounce are not recommended. (6) The limiting factor to the commercial life of the plants was the incidence of Yellow-edge virus. (7) The most important basis of runner selection, under these conditions, was freedom from disease. (W.S.R. and J.L.E.)

Uniformity Trials.

An examination of the data from two uniformity trials of strawberries has recently been completed and a report is in the press. It is shown that, in experimental work using clonal plants, fifty-plant plots as nearly square as possible, repeated four times, will give reasonable accuracy. The importance of keeping the plants healthy in order to make use of this result is, however, emphasized. (See also 63.) (J.L.E. and T.N.H.)

Effect of Age of Parent.

Previous work is now being summarized, and a large-scale trial comparing runners from one-year-old and two-year-old parents has been planted. (W.S.R.)

57. Planting, etc.

Time of Planting in relation to Warm Water Treatment.

A further repetition of the trial of warm water treated and untreated runners planted monthly from September to April has confirmed previous results, that early autumn is most satisfactory under our conditions. Planting conditions have been good up to mid-November in some years, but planting in December or January after warm water treatment is very risky. (W.S.R.)

Effect of Planting Strawberries after Strawberries.

Another crop will be obtained in this trial before the data are presented. (W.S.R.)

Burning in Relation to Pest Control and Cropping.

Observations, made prior to and after burning the straw litter directly after fruiting in the strawberry beds, show that the aphid and red spider population is materially reduced if the burning is thorough. It is important that the burning should be done when the weather conditions are suitable. (W.S.R. and A.M.M.)

Distance of Planting.

The distance of planting trial combined with manuring (see 60 below) gave a good crop in 1937. The widest spaced plants gave the highest crop per plant, but the closest

spaced plants gave the highest crop per acre. A heavy attack of Botrytis rot, favoured by damp conditions at picking time, destroyed about 15 per cent. of the whole crop. Wide spacing between plants reduced this loss, and close spacing increased it. The desirability of sufficiently wide spacing to give good air circulation is evident.

(W.S.R.)

Irrigation.

Artificial irrigation was experimentally applied on certain plots in two relatively dry periods, one before cropping and one after. Heavy rainfall followed the first application, but some interesting results have been obtained. This trial will be carried further.

(W.S.R.)

60. Manuring.

The manurial trial, the treatments of which were described in last year's Report, cropped well in 1937. Suggestive, but not very large, differences were found between certain treatments.

In another trial comparing farmyard manure with no manure, the former gave greatly improved results. Further records will be obtained before conclusions are published. (W.S.R.)

78. Virus Diseases.

Field Experiments.

The field study of Yellow-edge symptoms in Royal Sovereign has been extended to include comparison of a clone, uniformly infected with a mild strain of Yellow-edge, with other clones infected with more severe strains of this disease. Particular attention has been paid to an apparent high-resistance of the former to deterioration from virus possibly due to a protective action of the mild strain of virus employed. The results to date have shown considerable promise.

Parallel studies to the above using mild and severe Crinkle have been started.

The experiment in which virus incidence (in relation to various control measures) is being followed out under field conditions has been continued. Careful plant-to-plant observations of vigour and disease have been recorded. The spread of virus from infected plants to adjacent plants along the row has been very evident. This trial includes a farmyard manure treatment on half the plots. The plants on plots having no manure were less vigorous and developed virus symptoms more readily than those having farmyard manure. (R.V.H., A.M.M. and W.S.R.)

Transmission Experiments for Analysis of Symptoms.

Common Wild Strawberry (Fragaria vesca) as an Indicator of Virus Diseases.

Preliminary trials on the use of this species as an aid to rapid diagnosis of Yellow-edge and Mild Crinkle in field propagating beds have given encouraging results which will be followed up. (See 52.)

In pot experiments particular attention was paid to the reaction of *F. vesca* to the mild strain of Yellow-edge used in the field experiment to which previous reference has been made. The reaction of this species was also further compared with that of *F. virginiana.*

Owing to limited greenhouse accommodation the pot plants of the 1936 experiment with Royal Sovereign and *F. vesca* were transferred to the open ground early in 1937. Here they rapidly became infested with the aphis vector (*Capitophorus fragariae* Theob.)

following the appearance of the winged form in May ; as a result all the *F. vesca* indicators developed distinct symptoms of Yellow-edge early in July, and later the same symptoms appeared on the corresponding Royal Sovereign plants. It is interesting to note that the apparent immunity of *F. vesca* as determined under natural woodland conditions thus breaks down in pot culture. Further experiments have been arranged in exploration of this phenomenon.

The Etiology of Crinkle.

Further experimental data bearing on the relation between Severe Crinkle and Mild Crinkle were collected during the year and a summary of conclusions to date appears elsewhere in this Report.

Investigations of Virus Diseases in Ontario.

A preliminary paper has been published during the year and a summary of it appears on p. 79.

Transmissions to differential Hosts by Mechanical Methods.

Attempts were made to transmit virus diseases from strawberry plants to various solanaceous and leguminous plants by the inoculation of leaves with expressed juice. Positive results were obtained with Mild Crinkle on seedlings of tobacco (*Nicotiana tabacum*). (R.V.H.)

87. The Strawberry Tarsonemid Mite.

Control.

Experiments have been made to determine the value of a poison gas for fumigating mite-infested plants prior to planting them out. Further work on the same lines is in progress. (A.M.M. and R.M.G.)

89. Strawberry Aphid Investigations.

Aphid Transmission experiments and Period of Infectibility.

Further investigations show that the aphid (*Capitophorus fragariae* Theob.) is a vector of Yellow-edge and can transmit the disease during the months from February to October inclusive. A progress report has been published. (D127.)

In 1937 it was established that the same aphid is a vector of the virus of Mild Crinkle. Further work is in progress. (A.M.M.)

Life-cycle with special Reference to Alternative Hosts in the Field.

Much information has been obtained on the life-cycle of the aphid under natural conditions.

For example, the migration periods have been defined, and natural methods of spread in the field have been observed.

A search has been made for likely alternative host plants, and colonies of aphides have been established on wild plants which were inoculated artificially.

(A.M.M., R.M.G. and A.J.D.)

Control by Sprays and Dusts.

A good deal of time and thought has been given to the testing of insecticides, dusts and fumigants in an endeavour to control the aphid under field conditions. At present no substitute has been found for nicotine and soft soap.

The work is still continuing, and a special effort is being made to improve methods of application of sprays in the field. (A.M.M. and R.M.G.)

Technique for Estimating Aphid Population in the Field.

A method of estimating the aphid population in the field is being worked out. (R.M.G.)

90. Insects Feeding upon the Strawberry Plant.

A study is being made of the fauna of the strawberry with a view to finding possible vectors of the various virus diseases. A species of flea beetle, two or more species of leaf hoppers and a white fly were under observation during the year.

91. Warm Water Treatment.

Investigations on this treatment and possible alternatives are being continued. (A.M.M. and W.S.R.)

XI. LOGANBERRIES, BLACKBERRIES AND DEWBERRIES

(Combined Pomological and Pathological Investigations.)

43. Classification, Nomenclature and Variety Trials.

(*a*) Of the varieties included in a blackberry and dewberry collection, the Youngberry, thorned and thornless forms, and the Parsley Leaved Berry (*Rubus laciniatus*), both the true and a broad leaved variant, and John Innes, have borne very good crops. The fruit of these varieties was attractive in appearance ; the Youngberries were very large, averaging about 100 berries to the pound over the whole picking season, while the Parsley Leaved varieties and John Innes averaged about 175 to the pound. Ten other varieties bore moderate crops.

(*b*) The loganberry variants again showed considerable differences in amount and quality of crop.

(*c*) The blackberry seedlings from John Innes Horticultural Institute bore their first real crop this year. A number have given fruits of good appearance and flavour but none has, as yet, proved to be so vigorous or such a heavy cropper as any of the adjacent Himalaya plants.

(*d*) The main trial of Loganberry and Phenomenal Berry has yielded most interesting results during the past year. The Phenomenal Berry plants which were much smaller than the Loganberries in 1936 have now caught them up in cane growth but are still below them in amount of crop. The difference between the amount of crop of these two varieties is much less, however, than in 1936 and the fruit size of the Phenomenal Berries was once again considerably greater than that of the Loganberries. Samples of the fruit were used for canning trials carried out in collaboration with Mr. F. Hirst at the Fruit and Vegetable Preservation Research Station at Campden. The results obtained were similar to those of 1936 ; both varieties have good canning properties, the chief difference between them being in the colour of the product. Loganberries consistently gave a darker colour than Phenomenal Berries.

(*e*) The fruiting cane of about 10 per cent. of the plants in a trial of Himalaya and Black Diamond blackberries collapsed and died in full fruit in August, 1937. The fruit, leaves, cane and roots were examined immediately but no insect pests, fungi or bacteria to which this trouble could be attributed were found. The young cane remained alive and appeared to be healthy. The depth of the soil was examined and appeared to be sufficient for normal growth. Two plants of Himalaya, one healthy and one affected, were excavated in detail in November, 1937 (see 12, p. 44). Samples of the fruit from normal healthy plants of these two varieties were again sent to the Fruit and Vegetable Preservation Research Station, Campden. The fruit was canned and examined in detail as before. No difference in the canning quality of the two varieties could be detected. The Black Diamond clone has up to the present proved to be more vigorous in growth than the Himalaya clone, and the plants have given a significantly greater crop.

(A.B.B.)

53. Propagation.

A method of propagating Rubus fruits from deblossomed plants, by means of tips placed vertically in the soil in July and August, has proved successful for certain varieties such as the Loganberry, Phenomenal Berry, Himalaya, and King's Acre Berry. Other methods of propagation are being tried for the Parsley Leaved Berry, Youngberry and varieties of similar habit, which have been found to be difficult to root from tips.
(A.B.B. and R.J.G.)

58. Training.

Loganberry and Phenomenal Berry plants trained by two methods in which the plants are spaced at 6 feet apart in rows, again gave double the crop of similar plants trained by two methods at 12 feet apart. There were no great differences in cropping between the two methods of training with close spacing, or between the two for spaced methods. Detailed records of the incidence of Cane-spot disease on leaves and fruiting laterals in August, 1937, indicated that plants at 12 feet apart trained by weaving the cane on the wires were less severely affected than those trained one way, at 12 feet and 6 feet, or fan-trained at 6 feet apart. No great differences in vigour of canes between plants trained by these four methods were observed. (A.B.B.)

77b. Loganberry Cane-spot.

The disease attack in 1937 on a trial of Loganberry and Phenomenal Berry, unlike that of the preceding year, was very severe, particularly in the direct infection of fruiting laterals and berries. The spray treatment applied in 1936 was repeated and subsequent records of the incidence of the disease show (i) that Loganberry was more severely affected than Phenomenal Berry, and (ii) that the spraying gave a significant reduction in Cane-spot infection. For the effect of training method on the disease see 58 (above). (A.B.B., R.V.H. and M.H.M.)

104. Virus Disease of Blackberry and Loganberry.

An attempt was made to transmit (i) "Reversion" disease (or Blackberry "Dwarf") of Phenomenal Berry and Blackberry, and (ii) a "Mosaic" of Blackberry, to normal plants of Phenomenal Berry, Loganberry, Blackberry and Raspberry using the new method of cane-inarching. (See IX, Raspberries, 76.) These graft-combinations were entirely successful and are yielding positive results. (R.V.H. and A.B.B.)

86a. Blackberry Mites.

Investigation into the cause of "Red Berry" disease of blackberries is being held over until suitable material is available. According to American workers, a mite, *Eriophyes essigi* Hassan, is responsible for the "Red Berry" condition of the fruits.
(A.M.M. and G.H.L.D.)

86b. Studies of Insects infesting Species of Rubus.

See under Entomology, 86b.

Section III

PRELIMINARY RESEARCH REPORTS

POMOLOGY

THE WILD FRUIT TREES OF THE CAUCASUS AND TURKESTAN. THEIR POTENTIALITIES AS ROOTSTOCKS FOR APPLES AND PEARS

I. A FIRST REPORT ON SOME WILD QUINCE FROM THE CAUCASUS

By H. M. TYDEMAN

INTRODUCTION.

It is well known that, since prehistoric times, large forests containing wild deciduous fruit trees have existed in the Caucasus, in the regions between the Black and Caspian Seas, and in Turkestan, in the country contiguous to Afghanistan and China. Since these regions border very closely upon that in which the fruit trees of temperate countries are traditionally supposed to have originated, these trees may represent ancestral forms from which the present horticultural varieties have been evolved. They are being subjected to intensive study by workers under the Soviet Union and their researches should make an interesting contribution to our knowledge of the origin and phylogeny of the deciduous fruit tree species. At the same time, this material possesses very considerable interest from the purely horticultural point of view. It is quite possible that among the many millions of seedling fruit trees with which these areas are covered, some may be found which possess qualities of disease resistance, productivity or vigour which will make them of considerable value to the fruit grower.

In a paper read before the Ninth International Horticultural Congress, Vavilov (7) said : " The area of the wild apple tree is very extensive, it reaches from the Pyrenees to Tian-Shan. Not far from Tashkent entire woods composed of wild apples may be observed and have been described by V. V. Pashkevitch and A. P. Sigov (2) and M. G. Popov (3). The wild apples found in the Caucasus are fairly small. The wild apples of Turkestan, however, and especially those of Semirechye, are characterized by their comparatively large size. The capital town is called Alma Ata (the town Verny) which means ' City of Apples ', since the whole town is surrounded by forests consisting chiefly of wild apple trees. When crossing the boundaries of Northern Tian-Shan, the traveller passes for a long way through woods of wild apple trees. Individual trees bear fruit which in quality is not inferior to that of cultivated forms. Some are of astonishingly large size and exceptional productivity. The whole scale of transition from the typical small, sour apple to the cultivated, perfectly edible forms may be observed."

"In the forests of Azerbaijan (Eastern Transcaucasia) as well as in Eastern Daghestan, wild quinces may be observed in great numbers. The cultivation of the quince is at its highest here as far as the size of the fruit is concerned."

On several occasions, seed of apples, pears and quinces, collected from trees in certain of these areas, has been received at this Station, through the Department of Plant Introduction and New Cultures, U.S.S.R. Institute of Plant Industry, Leningrad. A number of plum seedlings from the Caucasus, Black Sea Region and Armenia have also been under trial here as rootstocks for plums and accounts of their behaviour have already been published (4, 5).

Germination of the Quince Seeds.

Six batches of quince seed, each collected from a single tree, were received from Russia, in the early part of 1931. They were sown immediately upon arrival in shallow wooden boxes and placed in an unheated greenhouse. The seed germinated during the autumn of 1931, and, as may be seen from Table I, a fair proportion of the seeds, amounting on the average to 79 per cent., germinated.

Table I.

Germination of Seeds of Wild Quince from the Caucasus.

Selection No.	Locality from which seed was obtained.	Number of seeds sown.	Number germinated.	Percentage germinated.
163	Caucasus, Daghestan, District Kayahent ..	40	38	95
164	,, ,, ,, ,, ,, ...	100	72	72
165	,, ,, ,, ,, ,, ...	90	64	71
166	,, ,, ,, ,, ,, ...	121	99	82
167	Caucasus, Daghestan, S. of the River Samour ..	100	80	80
168	,, ,, ,, ,, ,, ..	64	47	73

Since it was intended to test the suitability of these seedlings as rootstocks for pear varieties, as soon as they were large enough they were planted out in the open field at 2 feet apart in rows 3 feet apart. During the winter of 1933, they were cut down and mounded up to form stools, in order to ascertain how readily they would root when subjected to this method of vegetative propagation.

Growth and Rooting on the Stools.

The data on the growth and rooting of these seedlings when treated as stools are shown in Table II. Selections 166 and 167, in both the first and second years of stooling, produced the largest number of shoots per stool but, in the second year, those of 163 were slightly longer. Relatively few of the seedlings had produced well rooted shoots by the end of the first year after stooling but by the end of the second year, the proportion had greatly increased and amounted in 166 and 168 to almost 50 per cent.

The Variation of the Material.

Careful observations upon the botanical characters of these seedlings were made from the outset since it was of interest to know not only how far these wild quince seedlings were similar to the types of quince already in common use as rootstocks, but also the extent to which they varied among themselves. If it were possible to obtain

Table II.

Growth and Rooting of Wild Quince Seedlings as Stools.

Selection No.	No. of stools.	First year of stooling.							Second year of stooling.						
		Growth.			Rooting.				Growth.			Rooting.			
		Average total length of shoot per stool.	Average No. of shoots per stool.	Average length of each shoot.	Good.	Moderate.	Poor.	Percentage of good rooters.	Average total length of shoot per stool.	Average No. of shoots per stool.	Average length of each shoot.	Good.	Moderate.	Poor.	Percentage of good rooters.
		cm.		cm.				%	cm.		cm.				%
163	34	1017·6	11·7	86·9	1	5	28	2·9	1799·9	17·2	104·6	7	16	11	20·6
164	65	1061·8	12·5	84·7	3	9	53	4·6	1724·3	16·9	102·0	11	24	30	16·9
165	56	1248·3	12·2	102·3	0	8	48	0	2064·6	20·6	100·2	10	22	24	17·8
166	93	1099·0	14·2	76·9	1	7	85	1·1	1975·4	21·0	94·1	40	42	11	43·0
167	76	1398·0	13·1	106·8	5	22	49	6·5	2354·7	25·3	93·1	22	42	12	28·9
168	41	1095·1	12·6	87·2	1	20	20	2·4	2164·0	22·2	97·4	19	15	7	46·3

seedling races of rootstocks showing as great a degree of uniformity in their influence over the scion, as is shown by rootstocks raised asexually, the trouble and expense of vegetative propagation might be dispensed with. The work of attempting to produce such races artificially appears to be impracticable in the present state of our knowledge of the genetics of deciduous fruit trees, but there seems to be a distinct possibility, well worth exploring, that they might be obtainable from these regions of vast, natural fruit forests, where it might be presumed that a considerable degree of continuous inbreeding over long periods of time, might have eliminated variation. Indeed, Vavilov says: "As our investigations have shown, the periphery of the area of wild fruit tree species is usually characterized by a certain uniformity of forms."

In general, it may be said that these quince seedlings were strikingly uniform in most of their characters. As has already been shown, in their response to stooling, some variation was observable in the strength of growth and in the proportion of "good rooters", among the seedlings in each selection, but the differences were not markedly greater than are commonly found in any vegetatively produced race. The characters of the young vegetative shoots arising from the stools have been summarized in Table III. For comparison, Hatton's (1) description of similar shoots of Malling selected Quince C have been included in the table. With regard to most of the characters studied, no variation whatever was observable among the wild quince seedlings. Some variations were noted in the time at which they leafed-out in the spring, but the most striking differences were those associated with the folding of the leaf surfaces and the manner in which the leaves were held relative to the main axis of the shoot. It was possible to divide these quinces into five distinct groups on the basis of these differences. The majority of the seedlings bore leaves which were slightly concave, or upfolded along their midribs and which were drooping on their petioles (Type I in Table III). These are shown on the extreme right in Fig. 1. A second large class (Type II in Table III) consisted of seedlings in which the leaves were concave, or upfolded, but were held out horizontally relative to the axis of the shoot. These are illustrated on the extreme left in Fig. 1. The seedlings in this class were botanically very similar to Malling selected Quince C. Individuals of the remaining three types were far fewer than those of the first two types. Seedlings of Type III bore flat leaves somewhat drooping on the petioles. They are shown in the centre of Fig. 1. The seedlings of Type IV were very similar to Type I, with drooping leaves, but they were much more deeply concave. The fifth type consisted of individuals with flat leaves which were held out horizontally.

The number of seedlings belonging to each type is shown in Table IV. In the first three selections, individuals of Type I preponderated. Among the seedlings in the last three selections, plants of Types I and II were represented in approximately equal numbers. It is interesting to notice from Table II, that selections 166, 167 and 168, in which seedlings botanically closely similar to the weak growing Malling selected Quince C, occurred much more frequently than in the remaining selections, were actually less vigorous growing on the stools than were the other selections, but that they contained a larger percentage of good rooters, in the second year as stools. Interesting confirmation of the close similarity, at least with respect to certain botanical characters between these seedlings and Malling Type C, was obtained from measurements of leaf shape and petiole length. Measurements of the length and breadth of the lamina and of the length of the leafstalk were made on ten leaves from each of fifty stools of these seedling quinces, taken at random, comparable leaves from vigorous one year shoots being selected. The averages are shown in Table V, and for comparison, similar data for Malling Type C, compiled and published by Hatton (1). It will be seen at once that there was little difference between these wild quince seedlings and Malling selected Quince C, with

Table III.

Botanical Characters of Wild Quince from the Caucasus and of Malling selected Quince C.

	Malling Quince C.	Wild Quince from the Caucasus.				
		Type I.	Type II.	Type III.	Type IV.	Type V.
Bud bursting ..	Medium.	Variable.	Variable.	Variable.	Variable.	Variable.
Early leaves ..	Bright yellow.	Yellow green.	Yellow green.	Yellow green.	Yellow green.	Yellow green.
Growth habit ..	Dwarfing very erect.	Vigorous, very erect.	Vigorous, very erect.	Vigorous, very erect.	Vigorous, very erect.	Vigorous, very erect.
Shoots	Short, wiry.	Medium to long.	Medium to long.	Medium to long.	Medium to long.	Medium to long.
Internodes	Short.	Medium.	Medium.	Medium.	Medium.	Medium.
Leaves, Size ..	Rather small.	Rather small.	Rather small.	Rather small.	Rather small.	Rather small.
Shape ..	Broadly ovate.	Broadly ovate.	Broadly ovate.	Broadly ovate.	Broadly ovate.	Broadly ovate.
Surface ..	Crinkled, concave and downy.	Crinkled, slightly concave and downy.	Crinkled, concave and downy.	Flat, downy.	Crinkled, deeply concave and downy.	Flat, downy.
Colour ..	Dull, yellow green.	Medium to deep green.	Medium to deep green.	Medium to deep green.	Medium to deep green.	Medium to deep green.
Tip ..	Right angle, apex often obtuse.	Sharply tapering, apex obtuse.	Sharply tapering, apex obtuse.	Sharply tapering, apex obtuse.	Sharply tapering, apex obtuse.	Sharply tapering, apex obtuse.
Position on stem ..	Horizontal, slightly drooping.	Drooping.	Horizontal.	Drooping.	Drooping.	Horizontal.
Leaf Stalk	Short.	Short.	Short.	Short.	Short.	Short.
Stipules	Often longer than petiole, lanceolate entire.	Small, lanceolate entire.	Small, lanceolate entire.	Small, lanceolate entire.	Small, lanceolate entire.	Small, lanceolate entire.

TABLE IV.

NUMBER OF SEEDLINGS OF DIFFERENT BOTANICAL TYPES.

Selection No.	No. of seedlings.	Type I.	Type II.	Type III.	Type IV.	Type V.
163	34	21	6	3	3	1
164	65	46	8	1	7	3
165	56	39	6	7	1	3
166	93	39	37	11	1	5
167	76	18	34	10	0	14
168	41	16	15	4	0	6
Total	365	179	106	36	12	32

regard to the relation between the average length and breadth of the leaves and in the relation between lamina length and petiole length. As a further illustration of the extreme uniformity of these wild seedling quinces with respect to certain morphological characters, it may be mentioned that the coefficient of variability for leaf shape (i.e. breadth of lamina expressed as a percentage of length of lamina) was only 5·25 per cent. of the mean, and for the length of the leafstalks expressed as a percentage of the length of the lamina, as little as 1·86 per cent. of the mean. These values are considerably lower than have been found in some instances among vegetatively reproduced shoots of apples (6).

In general, then, these wild quinces have shown a degree of uniformity quite remarkable in material raised from seed. In many of their characters they appeared to resemble Malling Quince C very closely. The emergence of distinct types showing wide differences with regard to the folding of the leaf surface and the pose of the leaves, suggests that they were by no means homozygous for all characters, however.

COMPATIBILITY TESTS WITH PEAR VARIETIES.

It is well known that certain pears, of which Dr. Jules Guyot may be taken as the type, frequently make unsatisfactory trees when worked directly on to quince, either breaking out at the union after growing away apparently healthily for a few years, or failing to maintain sufficient growth to keep the tree in a profitable condition. Marie Louise may be taken as typical of a group of pear varieties which are even less satisfactory in combination with all the known selections of quince. Usually buds or grafts fail entirely to unite or, if a successful union is effected, the bud or scion rarely makes sufficient growth to form a satisfactory maiden tree. To overcome this incompatibility two methods are commonly resorted to. A second scion or intermediate of a variety which will grow directly on the quince, is placed between the quince rootstock and the incompatible variety or, as an alternative, the pear variety may be grown on a free pear rootstock. In practice, neither method is completely satisfactory at present. The use of an intermediate between the pear and quince adds greatly to the initial expense of raising the tree and introduces a factor, the influence of which upon the ultimate performance of the tree is at present little understood. The production of vegetatively raised races of seedling pear rootstocks, giving a satisfactory control over the growth and cropping of pear varieties, is being undertaken at this Station, but it is likely to be many years before races as easy to multiply vegetatively as the quince will have been evolved. There can be no doubt that selections of quince which will prove compatible

Table V.

Average Dimensions of the Leaves and Petioles.

Wild Seedling Quince and Malling Quince C.

	Number of seedlings.	Number of leaves.	Average length of lamina.	Average breadth of lamina.	Average length of petiole.	$\frac{\text{Breadth}}{\text{Length}} \times 100$	$\frac{\text{L. of petiole}}{\text{L. of lamina}} \times 100$
			mm.	mm.	mm.		
Wild Quince ..	50	500	47·14	40·69	6·07	86·32	12·99
Malling Quince C ..	—	—	47·70	41·60	6·40	87·21	13·42

with pear varieties like Williams's Bon Chrétien, Marie Louise or Dr. Jules Guyot would be extremely valuable.

Towards the end of 1936, it was decided to bud these quince seedlings with the three varieties of pear, Conference, Dr. Jules Guyot and Marie Louise, in order to see how far they might prove of value as rootstocks for varieties of pear which will not grow readily when united with the varieties of quince in common use at present. In order to economize space and time, a special technique was devised for budding these quinces with the three varieties of pear. The seedlings had been growing as stools for the previous three years and each stool had given rise to a number of vigorous shoots. They were left on the stools during the winter of 1935-6 and, during the autumn of 1936, buds were inserted into them while they were still growing on the stools. The shoots upon each stool were divided into three equal groups as similar in vigour as possible, and the shoots in each group were budded with a different variety. Each group of shoots was separated by a loop of wire and the varieties were identified by always being placed in a certain fixed order relative to a distinguishing mark placed on the wire. Only one bud was inserted into each stock and the number of stocks in each group varied according to the total number of shoots on each stool, but it was rarely less than five or six. Throughout their first year the buds grew upon the stocks while they were still attached to the stools and were not supported in any way. A number of these budded stools with the young maiden pears growing on them may be seen in Fig. 2.

In Table VI is shown the total number of shoots budded and the number and percentage of buds which grew away. In Conference a high percentage of the buds grew away successfully and there was comparatively little variation in this respect between the different selections of quince. In selection 168, a somewhat higher, and in 164, a rather lower percentage of buds was successful than the average. The take of Dr. Jules buds was not significantly lower than that of Conference but the three selections, 164, 165 and 166, had a rather smaller proportion of successful takes than the remainder. With Marie Louise, the proportion of buds which grew away was definitely smaller than with the other two varieties and there were marked differences in the percentage of successful takes in the various selections. In selections 163, 166 and 168, the proportion was not notably inferior to that obtained with Conference and Dr. Jules but in selections 165 and 167 it was considerably less. The data for bud-take on the individual stools has been arranged in the form of a frequency table. From this it can be seen that there were comparatively few stools upon which less than 50 per cent. of the buds of Conference did not grow away, and a relatively high percentage, actually 55 per cent. in which all the buds of this variety inserted, were successful. With Dr. Jules there was a larger proportion of stools upon which more than half the buds inserted failed to grow away and a much smaller proportion in which all the buds were successful. It is interesting to notice, however, that on only two stools out of the 365 involved in this experiment did all the buds of Conference fail to grow and all the buds of Dr. Jules failed on only one stool.

With Marie Louise, the proportion of stools which failed to take the bud at all was very much greater and those on which all the buds were successful, considerably less, than with the other two varieties. Actually more than half the buds grew away on only about 60 per cent. of the stools. Figs. 3-6 illustrate very clearly, typical incompatibilities between the quince stool and these three pear varieties.

A record of the length of growth made by each bud was obtained during the latter part of July, approximately a year after the buds were inserted. The shoots had not entirely stopped growing at the time when these measurements were made but losses from breaking out were becoming so frequent, particularly among the shoots budded with

Table VI.

First Year's Growth of Pear Varieties on Seedling Wild Quince from the Caucasus.

Selection Number.	No. of Seedlings.	Conference.					Dr. Jules Guyot.					Marie Louise.				
		No. of shoots budded.	No. of buds which grew.	Percentage take.	No. of maidens which broke out.	Average length per shoot.	No. of shoots budded.	No. of buds which grew.	Percentage take.	No. of maidens which broke out.	Average length per shoot.	No. of shoots budded.	No. of buds which grew.	Percentage take.	No. of maidens which broke out.	Average length per shoot.
						cm.					cm.					cm.
163	34	167	149	89·2	0	55·0	169	139	82·2	2	24·8	165	127	77·0	0	6·1
164	65	306	239	78·1	2	59·1	298	221	74·2	3	35·7	298	206	69·1	0	6·8
165	56	293	264	83·2	3	54·4	298	204	68·4	6	28·6	295	169	57·3	0	7·6
166	93	529	434	82·1	1	63·6	527	396	75·1	6	34·9	539	400	74·2	0	6·8
167	76	485	422	87·0	4	63·3	475	386	81·2	7	33·4	482	201	41·5	0	2·9
168	41	248	230	92·8	1	61·6	245	205	83·7	2	39·5	246	192	78·0	0	3·9

Table VII.

Frequency Table Showing Percentage Take of Buds on Individual Stools of Seedling Wild Quince.

Percentage take of buds.		Conference.											Dr. Jules Guyot.										Marie Louise.										
		100	90	80	70	60	50	40	30	20	10	0	100	90	80	70	60	50	40	30	20	10	0	100	90	80	70	60	50	40	30	20	10	0
Selection Number.	No. of stools.																																	
163	34	19	0	5	8	0	2	0	0	0	0	0	17	0	2	10	2	2	1	0	0	0	0	12	0	6	6	1	5	1	1	1	0	1
164	65	30	2	4	10	9	6	1	1	1	0	1	30	2	3	10	3	5	6	3	2	0	1	19	1	11	11	5	8	3	2	1	0	4
165	56	41	5	1	3	2	1	1	1	1	0	0	13	4	5	16	6	2	1	7	1	1	0	13	1	7	9	2	7	2	2	5	2	6
166	93	44	11	8	14	6	4	2	2	1	0	1	28	11	15	16	9	4	3	6	1	0	0	18	6	9	16	9	10	9	7	2	1	6
167	76	39	14	5	6	8	1	2	0	1	0	0	33	8	5	12	12	4	1	0	1	0	0	4	6	1	7	9	5	10	9	5	6	14
168	41	28	4	3	4	1	1	0	0	0	0	0	18	4	5	10	3	0	0	0	0	1	0	12	8	3	9	5	1	2	0	1	0	0
Total	365	201	36	26	45	26	15	6	4	4	0	2	139	29	35	74	35	17	12	16	5	2	1	78	22	37	58	31	36	27	21	15	9	31

Table VIII.

Frequency Table Showing Average Length of Growth in cm. from the Buds. Distribution on Individual Stools.

Average Length of Growth :		Conference.											Dr. Jules Guyot.											Marie Louise.										
		100	90	80	70	60	50	40	30	20	10	1	100	90	80	70	60	50	40	30	20	10	1	100	90	80	70	60	50	40	30	20	10	1
Selection Number.	No. of Seedlings.																																	
163	34	0	0	2	5	9	13	4	1	0	0	0	0	0	0	1	1	4	3	7	6	8	4	0	0	0	0	0	0	0	1	3	8	22
164	65	0	3	6	16	15	12	7	5	0	0	1	0	0	0	2	2	10	20	17	5	6	3	0	0	0	0	0	0	0	0	4	31	30
165	56	0	2	3	10	17	11	4	4	4	0	1	0	0	0	0	2	4	14	9	15	11	1	0	0	0	0	0	0	1	1	7	16	31
166	93	0	3	14	29	22	14	5	3	2	0	1	0	0	0	4	10	12	16	24	18	9	0	0	0	0	0	0	0	1	0	10	30	52
167	76	0	1	8	27	25	12	2	1	0	0	0	0	1	0	4	9	10	12	9	15	10	6	0	0	0	0	0	0	0	0	1	7	68
168	41	0	1	6	11	12	5	3	2	1	0	0	0	0	1	3	6	9	3	7	6	5	1	0	0	0	0	0	0	0	0	2	9	30
Total	365	0	10	39	98	100	67	25	16	7	0	3	0	1	1	14	30	49	68	73	65	49	15	0	0	0	0	0	0	2	2	27	101	233

Dr. Jules, that it was decided to obtain a record as soon as possible. A good many of the buds, particularly of Marie Louise, although apparently alive and healthy, had made no growth whatever, while others had made only a centimetre or less of growth and had then remained quite stationary. A frequent manifestation of incompatibility with Dr. Jules was the dying of the shoot, after it had made 40 or 50 centimetres of growth. The dead shoot remained attached at the union. The more typical breaking out at the union of apparently healthy and vigorous shoots occurred commonly as may be seen from Table VI. Even with Conference it was recorded occasionally but, as might have been expected, was much more frequent with Dr. Jules. On the aggregate, the losses from this cause were not, however, strikingly heavy. Of the 1,551 buds of Dr. Jules which grew away, only 26, or less than 2 per cent., broke out at the union.

There were wide differences in the average length of growth made by the budded shoots on the stools. Thus, with Conference, the buds worked on the three quince selections 166, 167 and 168 made slightly more growth, on the average, than the remainder. Upon the whole, the growth made by the shoots of this variety, with all selections of quince, would have been considered fairly good. The buds of Dr. Jules made only about one-half the growth made by the Conference buds. Shoots on stools of selection 168 appeared to be somewhat more vigorous than the majority and those on stools of 163 considerably less vigorous. The shoots budded with Marie Louise made disappointingly little growth on the average. Here again, the selections varied somewhat. The shoots from stools of 165 were the most vigorous and those on stools of 167 and 168, by a good deal the least.

In Table VIII, the average length of growth made by the shoots on the individual stools have been arranged in the form of a frequency table. If we take 50 centimetres quite arbitrarily, as the minimum permissible length of a usable maiden tree, then, as may be seen, 86 per cent. of the stools had produced maiden trees of Conference suitable for this purpose and the percentage was unquestionably greater by the time growth had finally ceased. Little difference in this respect was observable between the quince selections. With Dr. Jules, the proportion was strikingly less, only approximately 20 per cent. None of the stools budded with Marie Louise produced shoots 50 centimetres or more in length while 64 per cent. were less than 5 centimetres in length. Thus, for the production of a high proportion of plantable maiden trees, of Dr. Jules and Marie Louise, in the first year, these wild quinces may be regarded as no more promising than the selected quinces at present in commercial use.

It is interesting to correlate the vigour of these wild quince seedlings and that of the shoots of the pear varieties worked on to them. It might not unnaturally be supposed that the more vigorous the quince, the more vigorous would be the growth of the variety worked on it. Indeed, anyone desiring to select vigorous rootstocks from among a batch of mixed seedlings would be expected almost subconsciously to choose the more vigorous individuals. With these wild quinces, however, such a policy would have been a mistake. As may be seen from Table IX, where the quince stools are shown, arranged according to the average length of their own shoots, measured a few months before they were budded, the quinces were fairly variable in vigour, the average length of the shoots ranging from 50 to 140 centimetres but most of them were between 90 and 110 centimetres in length. Selections 163, 164 and 165 appeared to have a somewhat larger number of more vigorous stools than the remainder. In Table X, the correlation between the length of the shoots of the quinces and the length of the one-year shoots of the three varieties of pear worked on to them, is shown. In only a single instance, Dr. Jules on Quince 164, is there a significant correlation. Here, curiously enough, the correlation is comparatively great and the odds against its having been due to chance

Table IX.

Frequency Table Showing Number of Quince Stools with Shoots of Given Length.

Selection Number.	No. of stools.	Average length of shoots in centimetres.									
		140	130	120	110	100	90	80	70	60	50
163	34	1	2	6	15	4	4	2	0	0	0
164	65	1	3	5	16	24	10	5	1	0	0
165	56	1	2	10	10	15	12	5	1	0	0
166	93	0	0	5	12	25	32	16	3	0	0
167	76	0	1	0	8	21	32	13	1	0	0
168	41	1	1	3	7	11	12	4	1	0	1
Total	365	4	9	29	68	100	102	45	7	0	1

are considerable. With Marie Louise, any very striking correlation would hardly have been expected and it is somewhat surprising to notice that in 163 and 166, the correlations only just fall short of significance. When all the quinces are taken together, the correlation approaches significance even more closely. With Conference, where a fairly high degree of correlation might have been expected, none was actually found.

Table X.

Showing Correlation between Vigour of Quince Seedlings and Three Varieties of Pear Budded on them.

Quince Selection Number.	No. of stools.	Conference.	Dr. Jules Guyot.	Marie Louise.	Minimum Significant Correlation.
163	34	−·0515	·0256	·2893	·345
164	65	·0168	**·3095**	·0157	·249
165	56	−·1015	−·0011	−·0227	·267
166	93	·0386	·1894	·1651	·208
167	76	·0588	−·2092	·0324	·230
168	41	−·0002	·1066	·1768	·310
All together	365	−·0564	·0161	·1376	·149

(Significant correlation in heavy type.)

In these wild quinces at least, it seems apparent that the inherent vigour of the individual seedling bears little, if any, relation to its capacity for inducing vigour in the scion variety with which it is united, at least in the maiden year. Any attempt to grade out the individuals likely to make vigour inducing rootstocks, upon the basis of their own relative vigour, would quite evidently have been doomed to, at least partial, failure.

Acknowledgments.

The writer's thanks are due to Mr. R. J. Garner, who devised the technique for budding these quince seedlings upon the stools and who supervised the practical work connected with this trial throughout, to Mr. S. C. Pearce for working out the correlations

in Table X, and also to the various members of the Staff, who have assisted him from time to time with the recording.

Summary.

An account is given of 365 quince seedlings raised from six single tree selections, collected in the Caucasus, the seed being received from the Department of Plant Introduction and New Cultures, Leningrad, in 1931.

The growth and rooting of these seedlings, when treated as stools, is described. A fair proportion rooted satisfactorily and grew fairly vigorously.

Botanical descriptions of the chief types found among these seedlings are given, and one type, numerically fairly common in certain selections, resembled Malling Quince C very closely.

The stools were budded with three varieties of pear, Conference, Dr. Jules Guyot, and Marie Louise, during the autumn of 1936. The two latter varieties were used because they have proved incompatible with the varieties of quince in common commercial use and it was hoped to find varieties of quince compatible with them among these seedlings.

The " take " of the buds was fairly satisfactory with all the varieties of pear on most of the selections. While Conference made satisfactory growth with practically all the stools, Dr. Jules made unsatisfactory growth on most stools and very little growth was made by most of the Marie Louise buds.

Little correlation between the relative vigour of the unworked quinces and that of the pear varieties worked upon them could be found.

References.

(1) Hatton, R. G. " A First Report on Quince Stocks for Pears." Journ. Roy. Hort. Soc., 1920, **45,** 269-77.

(2) Pashkevitch, V. V. and Sigov, A. P. " Wild Forms of the Apple Tree in Chimgan." Bull. of Appl. Botany, 1928, **17,** 4.

(3) Popov, G. and M. " The Wild Apple Tree and *Prunus divaricata* in the Mountains of Chimgan." Bull. of the Middle Asiatic Univ., No. 11, 1925.

(4) Tydeman, H. M. " New Varieties of Rootstock for Plums. A Preliminary Report on Trials with Seedlings of *Prunus divaricata*." E. Malling Res. Sta. Ann. Rep. for 1933 (1934), 100-2.

(5) ——— " New Varieties of Rootstock for Plums, II. A Final Report on Seedlings of *Prunus divaricata*." E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 100-4.

(6) ——— " Variation in the ' Paradise ' Apple Rootstocks. A Study of Some Leaf and Shoot Characters in Four Races." Journ. Pom. and Hort. Sci., 1936, **14,** 19-25.

(7) Vavilov, N. I. " Wild Progenitors of the Fruit Trees of Turkistan and the Caucasus and the Problem of the Origin of Fruit Trees." Proc. IXth Int. Hort. Congress, London, 1930.

FIG. 1.
Vegetative shoots of seedling quince showing three distinct types of leaf pose.

FIG. 2.
General view of quince stools budded with three varieties of pear.

FIG. 3.

Stool budded with Conference (back right), Dr. Jules Guyot (left) and Marie Louise (in front), showing buds of all three varieties growing on Quince.

FIG. 4.

Stool budded with Conference (back right), Dr. Jules Guyot (left) and Marie Louise (front right), showing buds of Conference and Dr. Jules growing vigorously and buds of Marie Louise failed.

FIG. 5.

Stool budded with Conference (left), Dr. Jules Guyot (front), and Marie Louise (right), showing buds of Conference and Marie Louise growing away and buds of Dr. Jules Guyot failed.

FIG. 6.

Stool budded with Conference (right), Dr. Jules Guyot (back right), and Marie Louise (front), showing Conference failed, Dr. Jules growing away vigorously, Marie Louise growing weakly.

THE INFLUENCE OF DIFFERENT POLLENS ON THE GROWTH AND DEVELOPMENT OF THE FRUIT IN APPLES AND PEARS

I. A PROGRESS REPORT ON EXPERIMENTS CARRIED OUT DURING 1937

By H. M. TYDEMAN

INTRODUCTION.

The question of the possible influence of the pollen on the growth and character of the fruit has interested botanists for many centuries. There seems quite good reason, in the absence of evidence to the contrary, to suppose that the pollen may exercise quite a decisive influence in determining the growth and development of the fruit. Since the act of fertilization, in general, initiates the processes of growth in the fruit, the vigour and potency of the pollen may well be reflected in the rate at which the fruits grow or the time at which they reach maturity.

The problem is naturally a very wide one and has many aspects. It includes, at one extreme, the phenomena of sterility and sexual incompatibility, on which extensive researches have been undertaken during recent years (1, 2, 3). At the other extreme may be included all those cases, now very considerable, in which the pollen variety can be proved to have imprinted its characteristics upon the purely maternal tissues of the fruit. One of the clearest and simplest examples is that mentioned by Charles Darwin, in which the " St. Valery " apple, a variety which itself bore no pollen, when pollinated with any other variety, bore fruits like the pollen parent. The term " Xenia " has come to be applied to cases of this sort in which the characteristics of the male are, as it were, impressed upon the female. It will be clear, however, that there may be instances in which the pollen variety might alter the character of the fruit, possibly making it larger or more highly coloured, where the character, while unquestionably due to the pollen, was not necessarily a character actually possessed by the pollen variety. Bunyard (4) reports an experiment, in which a flower of Sandringham Apple, a variety with large faint stripes, pollinated by Bismarck, produced a fruit which ripened and fell off three weeks before other uncrossed fruits on the tree, and resembled a fine fruit of Cox's Orange Pippin. Most of the cases of so-called Xenia recorded in recent times fall into this category.

Perhaps the most extensive experiments of quite recent times are those of Nebel and his colleagues at New York (5, 6, 7, 8, 9), and Nebel and Kertesz's very comprehensive review of the subject (8) contains references to other work in the same field. Studies have not been confined to apples and pears but have included a wide range of other fruit-bearing plants. Although a number of experimenters have denied the existence of Xenia effects, there is an impressive accumulation of evidence in favour of the view that they do occur. In general, the effects reported in apples and pears have been concerned with differences in weight, colour and relative acidity of the fruits at maturity. In a recent paper (9) Nebel has recorded large differences in the storage

life of apple fruits pollinated by different pollens. Experiments have, however, been mainly confined to ascertaining the effect of pollens on the ultimate characteristics of the mature fruits. The weight of the fruit appears to have been used, almost universally, as the criterion of relative size, and for this reason it was not possible to obtain data upon the size of the fruits until they had been removed from the tree. Nowhere, so far as the writer has been able to discover, has any attempt been made to study the progressive development of fruits of apples and pears, pollinated by different varieties, from the time of pollination until maturity.

Facilities have been available at East Malling during the last few years for studying the effect of different pollens on the development and character of the fruit. Breeding work among apples and pears has been undertaken with the object of producing seedlings of economic value. It has been possible, gradually, to confine the pollination work to an orchard and pollination house and a series of trees, in pots, have become available. Three or four different varieties of pollen are frequently applied to the flowers on such trees and an efficient method of marking the flowers and fruits has been devised. The small size of the trees makes it possible to observe details on the fruits, and the use of an orchard house has made the labour of bagging flowers and fruits unnecessary. It has also made an intricate system of labelling possible without the danger of weather conditions destroying the identification marks. In considering the results, it must be remembered that data obtained from such trees may not be applicable to trees growing out of doors. If the effect of individual pollens can be seen on fruits differently pollinated, but growing upon the same tree, it seems to be of little real importance under what conditions the tree was growing. Certain interesting general tendencies in the cycle of growth or dropping of the fruits on these trees may, however, have been affected by the conditions under which they were growing. How far trees growing under more natural conditions are similarly affected, remains to be seen.

The Experiments.

The experiments were carried out during 1937 and the pollinations were made in an insect-proof pollination house into which the trees were removed when the flowers were about to open. The flowers which were intended for developing into fruits were emasculated by removing their stamens, and the different pollens used on any one variety were applied upon the same day and within as brief a time as possible, all the flowers upon the tree being used. In only two instances, discussed later, was this found to be impracticable because of the different times at which the two varieties, intended as seed and pollen parents respectively, opened their blossoms. The pollen was extracted from the unopened anthers of mature flowers and applied directly to the stigmas on the point of a dissecting needle which was sterilized each time before being used for fresh pollen. Measurements of the maximum diameter of the fruits were made at intervals during the growing period with a pair of graduated callipers, and a final weight and count of seeds was obtained when the fruits had reached maturity. The results, for the apple varieties, are summarized in Table I and for the pear varieties in Table II.

The Results with Apple Varieties.

With apples the following combinations were studied :

D1.	Devonshire Quarrenden	pollinated	by	White Transparent.
D2.	,,	,,	,,	Laxton's Superb.
D3.	,,	,,	,,	Cox's Orange Pippin.
D4.	,,	,,	,,	Worcester Pearmain.

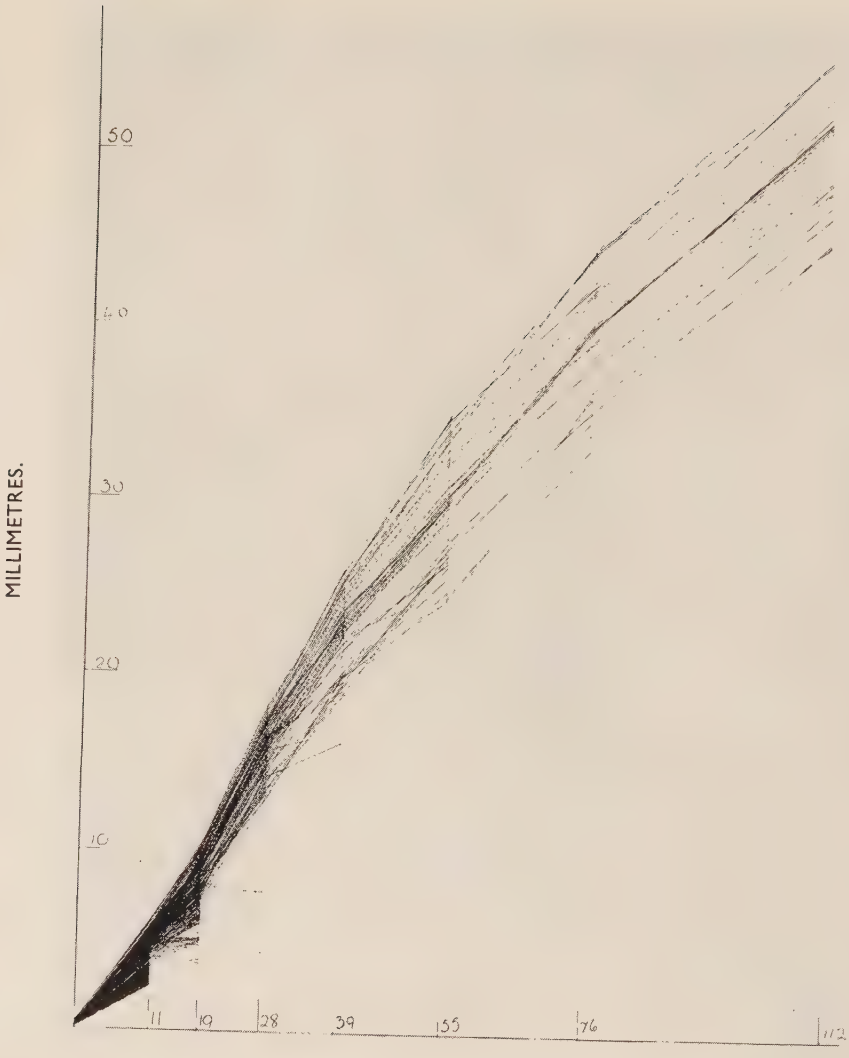


DIAGRAM A.

Devonshire Quarrenden pollinated with four different pollens.
Illustrating the development of each fruit.

S1.	Stirling Castle	,,	White Transparent.
S2.	,, ,,	,,	Worcester Pearmain.
S3.	,, ,,	,,	Laxton's Superb.
S4.	,, ,,	,,	Cox's Orange Pippin.
T1.	Transparente de Croncels	,,	Worcester Pearmain.
T2.	,, ,,	,,	Cox's Orange Pippin.
T3.	,, ,,	,,	Laxton's Superb.
M1.	Winter Majetin	,,	Cox's Orange Pippin.
M2.	,, ,,	,,	Worcester Pearmain.
P1.	Worcester Pearmain	,,	Devonshire Quarrenden.
P2.	,, ,,	,,	White Transparent.
P3.	,, ,,	,,	Transparente de Croncels.
W1.	White Transparent	,,	Devonshire Quarrenden.
W2.	,, ,,	,,	Cox's Orange Pippin.

(*a*) *Devonshire Quarrenden.*

Of the 459 flowers of this variety pollinated, 308, or 67 per cent., had set fruitlets by the 11th day after pollination. The proportion of flowers which set varied somewhat with the different pollens ; it was greatest in D1 with 83 per cent., and least in D4, with 53 per cent. A measurement of the diameters of all the fruits was taken on the 11th day and the averages are shown in col. 8, Table I. The fruits of D1 were the largest and those of D4 the smallest, and the difference between them was 1·75 mm. or 42 per cent. of their mean.* This difference is surprisingly large to have been found so early. By the 39th day, only about one-quarter of the fruits which were on the tree on the 11th day remained and the difference in average size between the fruits of D1 and D4 was only 1·57 mm. (7·7 per cent.). Between the 11th and 39th days, there had been a progressive reduction in the difference between the two sets of fruits. Throughout this period there was a continuous drop of fruits, and, in every instance, as the Table shows, these dropped fruits were smaller than those which remained. There was a clear pollen influence on the size of these dropped fruits even as early as eleven days after pollination, since the drops of D1 were distinctly larger than those of D4. It seems probable therefore that these dropped fruits were fertilized. Some part of the reduction of the difference in size between fruits of D1 and D4 which took place between the 11th and 39th days, appears to have been brought about by this fruit drop. For instance, between the 11th and 19th days, 34 fruits of D1 fell and 48 fruits of D4. In both cases these drops were smaller on the average than were all the fruits in their respective families. The loss of the larger number of smaller D4 fruits would naturally tend to raise the average of the D4 fruits which remained to a greater extent than the loss of fewer D1 fruits would have raised the average of the remaining D1 fruits. In this way the difference in average size between the two families would be reduced. This principle can be seen in operation with great frequency during the earlier stages in the development of the fruits in all the families studied. The earlier stages in the development of the fruits are well illustrated in Diagram A.

The fruits reached maturity on the 112th day after pollination and approximately 11 per cent. of the flowers pollinated gave rise to fully developed fruits. There was a difference between the average size of fruits of D1 and D4 of 2·07 mm. (4·2 per cent.). Thus, the difference of 42 per cent., found on the 11th day, had been reduced to just one-tenth by the time the fruits had reached maturity. As was to have been expected,

* Here, and subsequently, the difference between any pair compared is expressed as a percentage of the mean diameter of the two on the day when the comparison is made.

the difference in average weight was considerably greater, 5·76 grammes (7·6 per cent.). There were considerable differences in average seed content in the fruits in the four families; D1, with the larger fruits, had the larger number of seeds, and D4, with the smallest fruits, had the least. The large initial differences in fruit size may, therefore, have been the reflection of differences in seed content.

The development of the fruits of D2 and D3 have not been dealt with in detail, but the data are shown in Table I. In general, they occupied an intermediate position between D1 and D4.

(*b*) *Stirling Castle.*

By the 9th day, 45 per cent. of the pollinated flowers of Stirling Castle had set fruitlets and the difference in average size between those of S1 and S4 was 1·05 mm. (29 per cent.). By the 18th day the difference between these had increased to 2·66 mm. (41 per cent.). This result had been brought about because the fruits of S1, which fell between the 9th and 18th days, were smaller in comparison with all the fruits in this family, than were the fruits of S4, in comparison with all the fruits in that family. Although a larger number of fruits of S4 fell than of S1, the average of all the fruits of S1 was increased to a relatively greater extent. From the 18th day onwards there was a progressive diminution in the magnitude of the difference until the 52nd day (only 5 per cent.). As in Devonshire Quarrenden, the fruits which dropped were invariably smaller than those which remained.

The fruits of this variety were ripe on the 137th day after pollination and 5 per cent. of the flowers originally pollinated matured fruits. The difference in average diameter between fruits of S1 and S4 was only 1·15 mm. (less than 2 per cent.). Actually, the fruits of S1, which were slightly the larger, were lighter by 1·74 grammes. There was probably no significant difference at all between the two sets. There were approximately one and a half more seeds per fruit in S4 than in S1. Since the fruits of S1 were much larger than those of S4 during the earlier stages of their development, this suggests that fruit size at this stage cannot invariably be related to seed content.

Very few fruits of families S2 and S3 remained on the tree until the end. During the earlier stages they generally occupied a position intermediate between S1 and S4, although they were somewhat smaller than S4, from the 25th day onwards.

(*c*) *Transparente de Croncels.*

343 flowers of Transparente de Croncels were pollinated and ten days later 30 per cent. of them had set fruitlets. There was a difference in average diameter between fruits of T1 and T3 of only 0·57 mm. (11 per cent.). Between the 10th and 52nd days the smaller fruits dropped in considerable numbers and by the 52nd day the difference between the size of the fruits of T1 and T3 was only 0·48 mm., or a little more than 1 per cent.

The fruits were mature by the 134th day and 24 fruits or about 7 per cent. of the flowers had survived until the last. Those of T3 had been slightly the larger since the 73rd day but by the time they were ripe the difference was only small, not quite 2 per cent. The fruits of T3 were also a little heavier than those of T1. The difference, 3·81 grammes, about 2 per cent., was not marked. Seeds were slightly more numerous in the fruits of T3 than in those of T1.

(*d*) *Winter Majetin.*

The large proportion of 93 per cent. of the flowers of Winter Majetin pollinated had set fruitlets by the 16th day after pollination. There was a considerable

TABLE I.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Seed Parent.	Pollen Parent	Reference Number	Date of pollination.	Number of flowers pollinated.	Number of days after pollination.	Number of fruits set	Average diameter of all fruits.	Average diameter of fruits which fell *	Average diameter of fruits which remained	Number of days after pollination.	Number of fruits set	Average diameter of all fruits.	Average diameter of fruits which fell *	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell.*	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell *	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of fruits thinned off tree.	Average weight of thinnings.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average weight of all fruits.	Average number of seeds per fruit.
							mm.	mm.	mm.			mm.	mm.	mm.			mm.	mm.	mm.			mm.	mm.	mm.			mm.		gm.			mm.			mm.			mm.			mm.	gm.	
Devonshire Quarrenden ..	White Transparent ..	*D1*	9 4 37	121	11	101	5·01	4·39	5·32	19	67	7·90	6·71	9·19	28	32	15·61	15·40	15·62	39	31	20·95	13·53	22·73	55	25	29·32	7	10·66	76	18	38·83	—	—	—	—	—	—	112	18	50·61	46·52	9·17
,, ...	Laxton's Superb ..	*D2*	9–4–37	118	11	84	4·49	4·14	4·70	19	52	7·31	5·83	8·49	28	29	14·21	8·14	15·16	39	25	20·61	14·83	22·43	55	19	28·81	3	7·67	76	16	38·47	—	—	—	—	—	—	112	16	49·30	43·41	8·8
,, ...	Cox's Orange Pippin ..	*D3*	9–4–37	104	11	62	4·24	3·29	5·03	19	34	7·52	6·43	8·38	28	19	13·85	9·22	16·02	39	14	21·79	7·60	22·06	55	13	30·28	3	10·60	76	10	39·51	—	—	—	—	—	—	112	10	50·06	46·79	7·5
,, ,, ..	Worcester Pearmain ..	*D4*	9–4–37	116	11	61	3·26	2·99	4·26	19	13	6·35	5·34	7·53	28	6	14·18	—	14·18	39	6	19·38	21·00	19·32	55	5	27·75	0	—	76	5	37·78	—	—	—	—	—	—	112	5	48·54	40·76	6·40
Stirling Castle	White Transparent ..	*S1*	12–4–37	103	9	45	4·11	2·77	4·20	18	42	7·79	4·47	8·47	25	35	13·68	11·89	15·95	36	16	22·79	17·88	25·03	52	11	36·74	2	20·45	73	9	50·22	120	9	62·33	130	9	63·60	137	9	64·97	93·08	7·22
.. ..	Worcester Pearmain ..	*S2*	12–4–37	101	9	42	3·30	2·61	3·46	18	34	5·58	3·93	6·60	25	21	11·62	10·41	14·06	36	7	18·53	16·80	22·85	52	2	30·70	0	—	73	1	48·60	120	1	54·40	130	1	55·70	137	1	56·00	63·20	6·0
,, ,, ...	Laxton's Superb	*S3*	12–4–37	110	9	39	3·21	2·86	3·42	18	24	5·64	4·51	6·60	25	13	11·09	9·96	12·90	36	5	15·42	13·16	18·80	52	2	32·55	0	—	73	2	45·60	120	2	59·60	130	2	61·35	137	2	63·45	84·92	5·00
,, ,, ...	Cox's Orange Pippin ..	*S4*	12–4–37	96	9	56	3·06	2·58	3·28	18	38	5·13	3·22	6·52	25	22	12·14	10·27	13·01	36	15	19·65	13·10	22·93	52	10	35·92	2	12·25	73	8	51·64	120	8	61·04	130	8	62·76	137	8	63·82	94·82	8·75
Transparente de Croncels	Worcester Pearmain ..	*T1*	13–4–37	103	10	45	4·56	—	—	17	45	7·06	5·65	7·76	24	30	11·18	9·20	13·05	35	13	22·74	20·05	23·23	52	11	37·25	1	20·90	72	10	50·45	119	10	69·01	129	10	71·44	134	10	74·58	147·85	5·91
,, ,, ,,	Cox's Orange Pippin ..	*T2*	13–4–37	131	10	35	4·49	3·07	4·62	17	32	7·43	5·29	8·03	24	25	11·36	9·64	13·22	35	12	21·99	16·20	23·15	52	10	37·68	2	20·10	72	8	52·09	119	8	68·76	129	8	72·99	134	8	73·21	135·96	7·71
,, ,, ,,	Laxton's Superb	*T3*	13–4–37	109	10	23	3·99	3·20	4·16	17	19	6·78	4·98	7·27	24	15	10·69	9·60	11·94	35	7	20·49	15·30	21·35	52	6	36·77	0	—	72	6	50·57	119	6	70·16	129	6	73·78	134	6	75·98	151·66	6·16
Winter Majetin	Cox's Orange Pippin ..	*M1*	14–4–37	56	16	52	4·68	3·92	5·05	24	35	8·63	7·45	9·61	34	16	16·47	12·24	18·99	—	—	—	—	—	51	10	31·38	2	12·50	71	8	44·00	128	8	67·84	—	—	—	147	8	72·70	145·66	8·10
,, ,, ...	Worcester Pearmain ..	*M2*	14–4–37	50	16	47	3·19	2·66	4·12	24	17	7·75	7·53	7·94	34	9	13·67	12·54	15·07	—	—	—	—	—	51	4	26·42	0	—	71	3	40·87	128	3	62·60	—	—	—	147	3	70·23	131·02	2·30
Worcester Pearmain ..	Devonshire Quarrenden	*P1*	9–4–37	94	12	10	5·03	4·65	5·13	21	8	6·39	5·78	8·20	29	2	14·90	—	—	39	2	23·45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
,, ,, ..	White Transparent ..	*P2*	9–4–37	91	12	31	4·11	3·83	4·42	21	15	4·74	4·51	7·90	29	1	14·10	—	—	39	1	22·22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
,, ,, ..	Transparente de Croncels	*P3*	9–4–37	123	12	24	3·88	3·75	4·05	21	11	4·32	4·32	—	29	0	—	—	—	39	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
White Transparent ..	Devonshire Quarrenden	*W1*	7–4–37	54	12	53	5·29	3·58	5·52	23	49	10·12	7·03	11·91	31	31	16·87	15·01	20·32	41	11	27·02	—	—	56	11	38·08	4	19·22	78	7	54·84	—	—	—	—	—	—	101	7	65·30	96·24	7·29
.. .. ..	Cox's Orange Pippin ..	*W2*	12–4–37	134	7	125	4·21	3·02	4·33	18	113	8·10	6·18	9·11	26	74	13·09	11·15	17·33	36	34	24·06	20·43	24·84	51	28	36·63	12	19·54	73	16	52·47							96	16			

* Those fruits which fell between this and the next subsequent time of measuring.

the difference in average w
There were considerable c
families; D1, with the lar
smallest fruits, had the lea
have been the reflection of

The development of
but the data are shown in
between D1 and D4.

(*b*) *Stirling Castle.*

By the 9th day, 45
fruitlets and the difference
(29 per cent.). By the 18t
(41 per cent.). This resul
between the 9th and 18th
family, than were the fru
Although a larger number
S1 was increased to a relat
a progressive diminution in
5 per cent.). As in Devo
smaller than those which

The fruits of this va
cent. of the flowers origi
diameter between fruits of
the fruits of S1, which we
was probably no significan
mately one and a half mor
much larger than those of
that fruit size at this stag

Very few fruits of fa
the earlier stages they ger
although they were somew

(*c*) *Transparente de Cronc*

343 flowers of Transp
cent. of them had set frui
fruits of T1 and T3 of only
the smaller fruits dropped
between the size of the frui
cent.

The fruits were matu
flowers had survived until
73rd day but by the time
cent. The fruits of T3 w
3·81 grammes, about 2 pe
in the fruits of T3 than in

(*d*) *Winter Majetin.*

The large proportion
had set fruitlets by the

difference in average size between the fruits of M1 and M2 on the 16th day, amounting to 1·49 mm. (38 per cent.). This difference gradually grew smaller but, by the 51st day, it was still relatively large, 4·96 mm. (17 per cent.). Between the 51st and 147th days the difference was still further reduced and when the fruits had reached maturity, the difference in size between the two families was only 2·47 mm. (about 3·4 per cent.). The difference in average weight was much greater, 14·64 grammes (about 11 per cent.). There was a very marked difference in the seed content of the fruits in the two families. Fruits of M1 had almost four times as many seeds as fruits of M2.

(*e*) *Worcester Pearmain.*

Only the earlier stages in the development of the fruits of this variety could be studied because, following the 29th day, all but three of the fruits fell. Of the 308 flowers pollinated only 21 per cent. set fruitlets by the 12th day. There was a noticeable difference in extreme size between these fruits; between P1 and P3 it was 0·9 mm. (21 per cent.). By the 21st day, two fruits of P1 and thirteen of P3 had fallen. These fruits were only slightly smaller than the whole of the fruits in these two families. In spite of this, the difference between the two sets had considerably increased by the 21st day and was actually 2·07 mm. (almost 39 per cent.). Between the 21st and 29th days, all the fruits of P3 and all but two of the fruits of P1 fell and no further records could be obtained.

(*f*) *White Transparent.*

The story of White Transparent is a particularly interesting one. It was originally intended to have pollinated this variety with Devonshire Quarrenden and Cox's Orange Pippin upon the same day, but the pollen of Cox was not available, and it was not found possible to apply the Cox pollen until five days after that of Devonshire Quarrenden. In W1, 98 per cent. of the flowers had set fruitlets by the 12th day after pollination and in W2, 93 per cent. had set by the 7th day. On the 19th of April, there was a difference in size between the two sets of fruits of 1·08 mm. (22 per cent.). This is a surprisingly small difference considering the comparatively wide interval between the times when the two pollens were applied and is considerably less than that between fruits from different pollens applied at the same time, with most of the varieties already discussed. It is necessary to remember that at identical times the fruits of W2 were actually larger, on the average, than those of W1. This is shown more clearly in Diagram B. Between the 19th and 30th of April, four fruits from W1, and twelve fruits from W2 fell and, by the latter date, the difference in size between the two sets remained unchanged. This was due to the fact that the fruits of W1 which fell were smaller in comparison with all the fruits of this family than were the fruits of W2 when compared with all the W2 fruits. Thus the larger drop of the latter fruits did not, in this instance, reduce the difference between W1 and W2. Between the 30th April and the 8th May, eighteen fruits of W1 and thirty-nine fruits of W2 fell, and the difference in size between the two families of fruits was reduced, by the latter date, to 12 per cent. Thereafter, the difference was consistently reduced until, by the 24th June, the 56th day after pollination in W1, and the 51st in W2, it was rather less than 4 per cent. of their mean.

By the 10th July, the 101st day after pollination in W1 and the 96th in W2, the fruits were mature. Of the 188 fruits originally pollinated, twenty-three, or about 12 per cent., gave rise to fruits which persisted until the end. There was a difference of only 1·33 mm. (slightly more than 2 per cent.) between their average diameters. The difference in average weight was considerably greater, 13·61 grammes (15 per cent.).

Seeds were slightly more numerous in fruits of W1 than in those of W2 ; the excess was not great, amounting to only approximately half a seed per fruit, on the average.

The Results with Pear Varieties.

In pears, the following combinations were studied :

B1.	Williams's Bon Chrétien	pollinated with	Beurré Superfin.
B2.	,, ,,	,,	Clapp's Favourite.
B3.	,, ,,	,,	Fertility.
B4.	,, ,,	,,	Dr. Jules Guyot.
E1.	Beurré Superfin	,,	Fertility.
E2.	,, ,,	,,	Clapp's Favourite.
E3.	,, ,,	,,	Williams's Bon Chrétien.
E4.	,, ,,	,,	Dr. Jules Guyot.
J1.	Dr. Jules Guyot	,,	Clapp's Favourite.
J2.	,, ,,	,,	Williams's Bon Chrétien.
F1.	Fertility	,,	Williams's Bon Chrétien.
F2.	,,	,,	Clapp's Favourite.
V1.	Vicar of Winkfield	,,	Williams's Bon Chrétien.
V2.	,, ,,	,,	Dr. Jules Guyot.

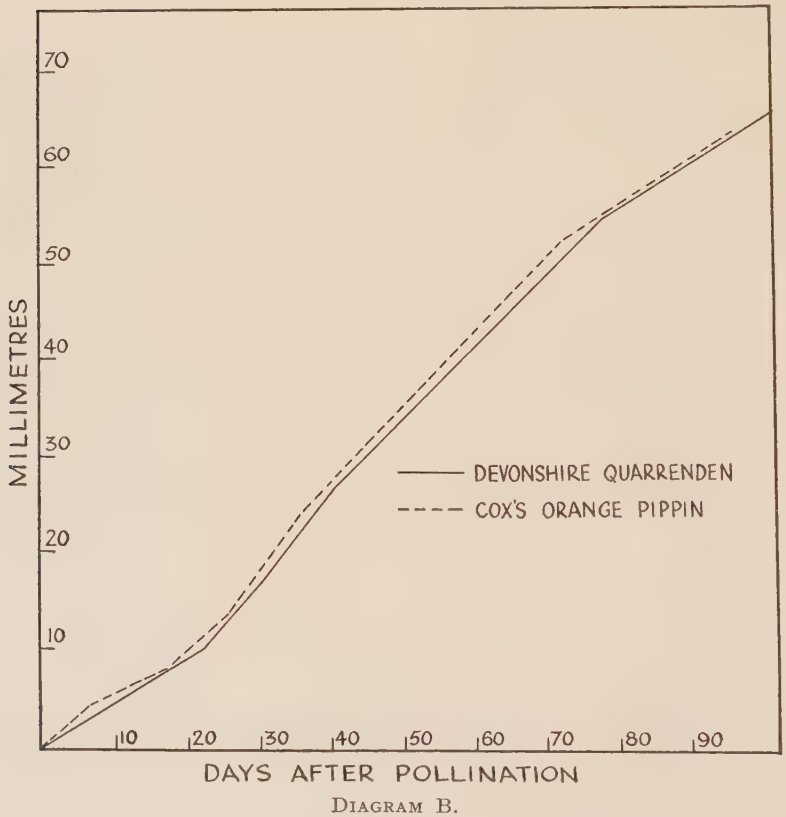


Diagram B.

Average growth of fruits of White Transparent pollinated on different days.

TABLE II.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Seed parent.	Pollen parent.	Reference Number.	Date of pollination.	Number of flowers pollinated	Number of days after pollination	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell.*	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell.*	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell.*	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average diameter of fruits which fell.*	Average diameter of fruits which remained.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Number of fruits two to a spur.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Number of days after pollination.	Number of fruits set.	Average diameter of all fruits.	Average weight of each fruit.	Average number of seeds per fruit.
							mm.	mm.	mm.			mm.	mm.	mm.			mm.	mm.	mm.			mm.	mm.	mm.			mm.				mm.				mm.			mm.	gm.	
Williams's Bon Chrétien ..	Beurré Superfin	*B*1	2–4–37	80	15	55	7·91	7·17	9·43	27	18	12·94	11·49	14·59	36	9	16·32	14·52	18·58	46	4	17·85	—	17·85	61	4	31·60	83	4	0	45·45	—	—	—	130	4	75·35	214·5	—
,, ,, ,, ..	Clapp's Favourite ..	*B*2	2–4–37	118	15	70	7·89	6·94	8·64	27	39	11·78	10·77	13·43	36	12	14·22	13·62	17·20	46	2	20·20	17·90	22·60	61	1	31·20	83	1	0	44·60	—	—	—	130	1	74·80	233·9	—
,, ,, ,, ..	Fertility	*B*3	2–4–37	88	15	50	7·08	6·57	8·09	27	17	11·91	11·25	12·95	36	7	13·10	13·10	—	46	0	—	—	—	61	0	—	83	0	0	—	—	—	—	130	0	—	—	—
,, ,, ,, ..	Dr. Jules Guyot	*B*4	2–4–37	108	15	49	6·95	6·40	7·98	27	17	10·82	10·27	11·96	36	5	12·92	11·92	16·90	46	1	20·90	—	20·90	61	1	30·20	83	1	0	42·70	—	—	—	130	1	73·20	112·3	—
eurré Superfin	Fertility	*E*1	1–4–37	163	16	41	8·00	7·81	8·48	28	12	12·91	11·25	13·74	37	8	16·71	13·30	18·92	47	5	23·10	—	23·10	63	5	30·50	85	5	0	45·16	142	5	71·50	147	5	73·58	202·3	4·2
,, ,, ...	Clapp's Favourite ..	*E*2	1–4–37	155	16	54	7·40	7·29	7·95	28	9	12·22	10·27	13·20	37	6	15·35	12·65	16·85	47	4	19·33	14·40	21·80	63	3	29·33	85	3	0	41·87	142	3	66·97	147	3	70·30	181·1	6·0
,, ,, ...	Williams's Bon Chrétien	*E*3	1–4–37	165	16	32	6·68	6·34	7·89	28	7	12·96	9·70	13·50	37	6	17·17	11·50	18·42	47	5	22·22	—	22·22	63	5	30·00	85	5	0	42·68	142	5	68·58	147	5	70·38	186·7	6·6
,, ,, ...	Dr. Jules Guyot	*E*4	5–4–37	163	12	18	7·52	7·18	7·65	24	13	12·66	10·63	13·57	33	9	16·18	14·33	17·25	43	6	19·93	15·50	20·82	59	5	28·51	81	5	0	40·36	138	5	62·58	143	5	67·20	161·7	2·0
Dr. Jules Guyot	Clapp's Favourite ..	*J*1	2–4–37	92	18	30	7·85	7·11	8·59	27	15	9·39	9·19	10·70	34	2	13·10	11·80	14·40	46	1	20·00	—	20·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
,, ,, ,, ...	Williams's Bon Chrétien	*J*2	2–4–37	97	18	28	7·31	6·87	7·99	27	11	8·61	8·47	10·00	34	1	12·50	—	12·50	46	1	17·60	—	17·60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fertility	Williams's Bon Chrétien	*F*1	1–4–37	86	19	48	11·86	7·40	11·94	28	47	14·57	13·16	15·17	37	33	17·55	14·27	19·96	47	19	22·90	16·70	23·27	63	18	30·71	85	18	6	42·59	142	18	64·66	147	18	67·09	160·2	3·6
,, ...	Clapp's Favourite ..	*F*2	1–4–37	61	19	24	10·65	7·57	11·09	28	21	13·90	12·08	14·33	37	17	17·15	15·61	18·23	47	11	21·43	18·10	21·52	63	10	28·27	85	10	2	40·25	142	10	62·24	147	8	65·59	146·6	3·7
Vicar of Winkfield ..	Fertility	*V*1	1–4–37	36	19	31	11·10	—	—	21	31	11·83	9·10	12·38	35	26	15·88	15·03	19·58	47	5	21·08	20·92	21·70	63	1	26·20	–	–			–	–			–	–	–	–
,, ,, ..	Dr. Jules Guyot	*V*2	1–4–37	39	19	36	9·09	—	—	21	36	10·41	8·29	11·75	35	22	15·38	14·07	18·19	47	7	19·46	19·46	—	63	0	–				–							–	–	–

* Those fruits which fell between this and the next subsequent time of measuring.

Se
gre

Although data on the earlier stages of the development of the fruits from all these crosses could be obtained, only in two varieties, Beurré Superfin and Fertility, was it possible to follow sufficient fruits through all the stages of growth to maturity, and so obtain a reliable estimate of the influence of the pollen on the fully grown fruits. This was due to the excessive dropping of immature fruits with most of the varieties studied. The same processes could, however, be seen in operation among these pear fruits, as those already described for the apples. Although the initial differences between the average size of the fruits, pollinated by different pollens, were, generally speaking, smaller than with the apples, probably due to the fact that with the pyriform pear fruits maximum diameter was a less efficient index of fruit size, precisely the same processes appear to have been involved in reducing them.

(*a*) *Williams's Bon Chrétien.*

Of the 394 flowers of this variety pollinated with four sorts of pollen, 224, or 57 per cent., had set fruitlets by the 15th day. There were considerable differences in size between the fruits and the most extreme difference was that between B1 and B4, of 0·96 mm. (almost 13 per cent.). Between the 15th and 36th days, an approximately equal number of B1 and B4 fruits fell and in both they were much smaller, on the average, than those which remained on the tree. The difference in average size between the two sets had increased very considerably by the 36th day and amounted to 3·4 mm. (23 per cent.). Between the 36th and 46th days, all but four of the fruits of B1, and one of the fruits of B2 fell, and no further reliable records were obtainable.

(*b*) *Beurré Superfin.*

646 flowers of Beurré Superfin were pollinated and, of these, 145, or 22 per cent., had set fruitlets by the 16th day. The largest fruits were those pollinated by Fertility (E1) and the smallest, those pollinated by Williams's (E3). The difference in average diameter was not large, 1·32 mm. (18 per cent.). Between the 16th and 28th days, twenty-nine fruits of E1 and twenty-five fruits of E3 had fallen. Although slightly smaller, they were not markedly dissimilar in size to the fruits of the same families which remained on the tree. By the 28th day, any difference in average size between the two sets of fruits had practically disappeared. Those of E3 were very slightly the larger but the difference of only 0·05 mm. (0·4 per cent.) was almost certainly not significant. By the 37th day, this difference had become slightly larger, the fruits of E3 being 0·46 mm. larger than those of E1. By the 63rd day, however, the fruits of E1 were again the larger, but the difference was hardly significant, being little over 1 per cent.

The fruits were ripe on the 147th day. Those of E1 were still the largest, the difference between them and those of E3 being 3·2 mm. (about 4 per cent.). In their weight, the difference was somewhat more pronounced, amounting to 15·6 grammes (about 8 per cent.). Seeds were actually more numerous in the fruits of E3 than in those of E1 by about two seeds per fruit.

The pollen of Dr. Jules was not applied to this variety until four days after that of the other varieties. Of the 163 flowers to which pollen was applied only eighteen, or 11 per cent., had set fruitlets by the 12th day. At this time, these E4 fruits were only 0·48 mm. smaller, or 94 per cent. of the size of the E1 fruits, which were four days older. In other words, the difference in size between the fruits of E1 and E4 was much less, in spite of the difference of four days in time of pollination than was that between E1 and E3 pollinated on the same day. Actually, age for age, the E4 fruits were larger than those of E1, at least during the earlier stages of their development, as can be seen from

Diagram C. The difference between the two sets of fruits remained negligible until the 47th day in E1, and the 43rd day in E4. It then, somewhat unexpectedly, increased to 3·17 mm. (about 15 per cent.). The difference remained large from that point until the end. On the 142nd day (E1) and 138th day (E4), it was 8·92 mm. (13 per cent.). The fruits were picked on the 147th day (E1) and 143rd day (E4) and the difference in average size was then 6·38 mm. (9 per cent.). There was a difference of 40·6 grammes (22 per cent.) between the average weights. There were far fewer seeds in the fruits of E4 than in those of E1. The result obtained in this variety by pollinating at different times by two distinct pollens is somewhat unusual, since the flowers pollinated later made relatively the larger fruits during the earlier stages of their development although they fell very far behind after they had become about half grown.

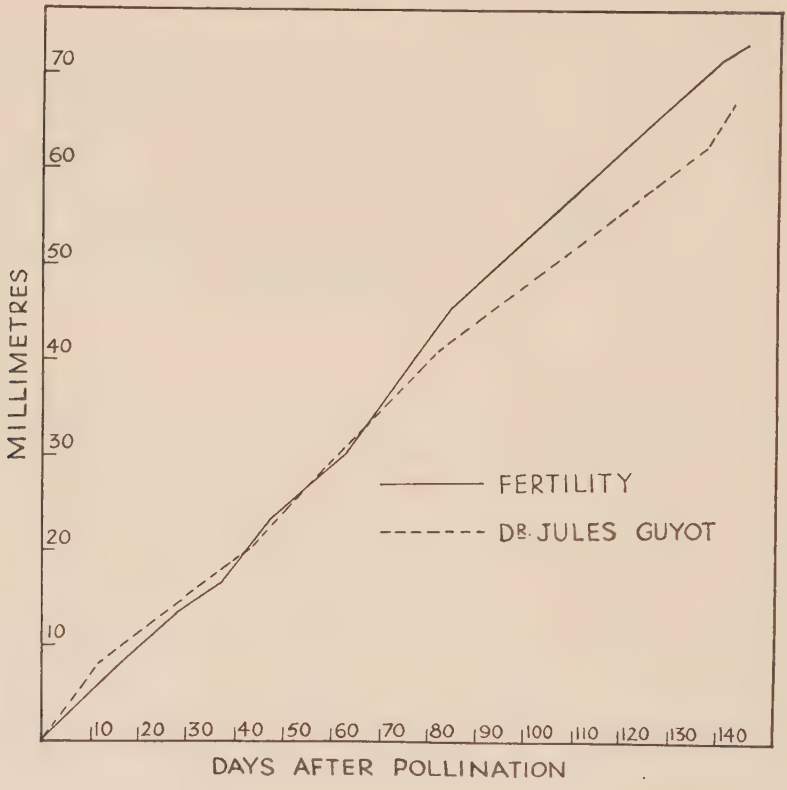


Diagram C.

Average growth of fruits of Beurré Superfin pollinated on different days.

(c) *Dr. Jules Guyot.*

Of 189 flowers of Dr. Jules Guyot, pollinated with two varieties of pollen, fifty-eight or 31 per cent. had set fruitlets by the 18th day. There was a difference in average size between the two groups of fruits of only 0·54 mm. (7 per cent.). About half of these fruits fell between the 18th and 27th days and there was little difference in the proportion of J1 and J2 fruits lost. On the 27th day the two sets of fruits differed in size by 0·78 mm. (4 per cent.). Between the 27th and 34th days all but two of the J1 fruits and all but one of the J2 fruits fell.

(*d*) *Fertility.*

147 flowers of Fertility were pollinated with two varieties of pollen and by the 19th day, seventy-two or about 50 per cent., had set fruitlets. The F1 fruitlets were the larger, on the 19th day, by 1·21 mm. or nearly 11 per cent. of their mean. Few fruits dropped until after the 28th day, but between the 28th and 47th days, more than half the fruits fell. They were slightly smaller, on the average, than those that remained. By the 47th day, the difference in size between the F1 and F2 fruits was 1·47 mm. (7 per cent.). The fruits were ripe on the 147th day and the difference in average diameter between the fruits in the two groups was then only 1·5 mm. (about 2 per cent.). With average weight, the difference was larger, 13·6 grammes (9 per cent.). There was practically no difference in the number of seeds contained by the F1 and F2 fruits.

(*e*) *Vicar of Winkfield.*

About 90 per cent. of the flowers of Vicar of Winkfield pollinated with Fertility and Dr. Jules had given rise to fruitlets by the 19th day. The fruits of V1 were the larger and the difference amounted to 2·01 mm. (20 per cent.). By the 35th day, five of the V1 fruits and fourteen of the V2 fruits had fallen and the difference in average size between those that remained was only 0·5 mm. (3 per cent.). Between the 35th and 63rd days, all the fruits except one had dropped.

Discussion.

In the foregoing an account is given of the growth, at various stages after pollination, of the fruits of six varieties of apples with eighteen pollinations and of five varieties of pears with fourteen pollinations. The story of the development of these fruits has been remarkably similar for all varieties. Unexpectedly large differences in average size between fruits of the same variety, crossed with different pollens, were found amounting, in D1 and D4, to as much as 42 per cent. at eleven days after pollination. In every instance, these differences had become much smaller by the time the fruits had reached maturity. The fruits dropped in great numbers during the earlier stages of growth, and, in every variety studied, the fruits which fell were smaller, on the average, than those which remained on the tree. This fruit drop was undoubtedly responsible, to some extent, for the reduction of the difference in size between sets of fruits pollinated by different pollens, between the earlier and later stages of their growth.

It is commonly asserted that all varieties of apple and pear pollen are equally effective as pollenizers provided they are diploid and available at the time when the blossoms of the female are in a receptive condition. The choice of pollinators in commercial orchards is largely based on this assumption. These experiments suggest, however, that this assumption is, to some extent, ill-founded. It is quite clear that with certain pollens a far larger proportion of flowers matured fruits than with others. The data have been set out in detail in Table III. For example, at the end of eleven days, Devonshire Quarrenden flowers, when pollinated by White Transparent, had set 83·5 per cent. and 14·9 per cent. reached maturity but, when pollinated by Worcester Pearmain, only 52·6 per cent. had set at eleven days and 4·3 per cent. reached maturity. The difference is equally striking with Stirling Castle and Transparente de Croncels among apples, and Fertility pear. There is evidently a very close parallel between the proportion of fruitlets maturing immediately after pollination and the number which reached maturity. As has already been pointed out, there is also a close relation between the size of the fruits immediately after pollination and the rate at which they drop. It may be, therefore, that apart from the larger sexual incompatibilities determined by

such major factors as triploidy and its related phenomena, there exist less striking affinities or incompatibilities between varieties of apparently similar chromosome constitution which manifest themselves in various degrees of partial unfruitfulness.

Certain American workers (10, 11) have reported differences in the seed content of fruits of the same variety from different pollen parents. In both cases it was stated that the heaviest fruits contained the fewest seeds. In the present experiments, with almost every variety, it was found that, on the average, the heavier fruits contained the larger number of seeds.

TABLE III.

SHOWING RELATION BETWEEN FRUITS SET SHORTLY AFTER POLLINATION AND FRUITS BROUGHT TO MATURITY.

Ref. No.	Seed parent.	Pollen parent.	No. of flowers pollinated.	No. of days after pollination.	Per cent. of fruits set.	Per cent. of fruits brought to maturity.
D1	Devonshire Quarrenden ..	White Transparent ..	121	11	83·5	14·9
D2	,, ,, ..	Laxton's Superb ..	118	11	71·2	13·5
D3	,, ,, ..	Cox's Orange Pippin	104	11	59·6	9·6
D4	,, ,, ..	Worcester Pearmain	116	11	52·6	4·3
S4	Stirling Castle	Cox's Orange Pippin	96	9	58·3	8·3
S1	,, ,, ...	White Transparent ..	103	9	43·7	8·7
S2	,, ,, ...	Worcester Pearmain	101	9	41·6	1·0
S3	,, ,, ...	Laxton's Superb ..	110	9	35·5	1·8
T1	Transparente de Croncels	Worcester Pearmain	103	10	43·7	9·7
T2	,, ,, ,,	Cox's Orange Pippin	131	10	26·7	6·1
T3	,, ,, ,,	Laxton's Superb ..	109	10	21·1	5·5
M2	Winter Majetin ..	Worcester Pearmain	50	16	94·0	6·0
M1	,, ,, ..	Cox's Orange Pippin	56	16	92·8	14·3
W1	White Transparent ..	Devonshire Quarrenden ..	54	12	98·1	13·0
W2	,, ,, ..	Cox's Orange Pippin	134	7	93·3	11·9
E2	Beurré Superfin	Clapp's Favourite ..	155	16	34·8	1·9
E1	,, ,, ...	Fertility ..	163	16	25·1	3·1
E3	,, ,, ...	Williams's Bon Chrétien ..	165	16	19·4	3·0
E4	,, ,, ...	Dr. Jules Guyot ..	163	12	11·0	3·1
F1	Fertility	Williams's Bon Chrétien ..	86	19	55·8	20·9
F2	,, ...	Clapp's Favourite ..	61	19	39·3	13·1

In only a few cases was it possible to see any very marked differences in size between fruits of the same variety differently pollinated, by the time they had reached maturity. The difference in weight was frequently somewhat larger and in at least three instances, Devonshire Quarrenden and Winter Majetin apples and Fertility pear, there is good evidence for supposing that the pollens had exerted differential effects on the weight of the mature fruits. The differences, which were of the order of 10 per cent., were sufficiently large to make them economically important. Further experimental work will be undertaken to confirm these results and to elucidate the causes of the phenomena described.

Summary.

This paper describes experiments, carried out during 1937, on the effect of different pollens on the development of the fruits of apple and pear varieties. Eighteen crosses between apple varieties and fourteen crosses between pear varieties were studied in detail, the fruits being measured at intervals from shortly after the time of pollination until they had reached maturity.

Comparatively large differences in the size of the fruits of each variety, fertilized by different pollens, were found within the first few weeks after pollination. These differences grew smaller as time went on and, by the time the fruits were ripe, had become almost negligible. It was possible to show that this reduction in size difference was associated with fruit drop. In all the crosses studied it was found to be the smaller fruits which fell, irrespective of the variety with which they had been pollinated.

The differences in final weight between fruits of any one variety differently pollinated, were found to be larger, sometimes of the order of 10 per cent. Rather large differences were also found in the average seed content of the fruits but it did not always follow that the larger fruits had the greater number of seeds.

In two crosses there was an interval of several days in the time at which two varieties of pollen were applied. In both of them the fruits derived from that variety of pollen which had been applied at the later date were the larger during the earlier stages of their growth but, in one instance, the earlier pollinated fruits were the largest by the time they reached maturity.

References.

(1) Crane, M. B. Journ. Pom. and Hort. Sci., 1926, **6,** 157-66.

(2) Crane, M. B. and Lawrence, W. J. C. Journ. Pom. and Hort. Sci., 1929, **7,** 276-301.

(3) ——— —— and ———— ——— Journ. Genetics, 1931, **24,** 97-107.

(4) Bunyard, E. A. Journ. Roy. Hort. Sci., 1900, **24,** 1,899.

(5) Nebel, B. R. New York Agric. Exp. Sta. Tech. Bull. **170,** 1930.

(6) Nebel, B. R. and Trump, I. J. Proc. Nat. Acad. Sci., 1932, **18,** 356-9.

(7) Nebel, B. R. Proc. 6th Int. Cong. Genetics, 1932, **2,** 140-1.

(8) Nebel, B. R. and Kertesz, Z. I. Gartenbauwiss., 1934, **9,** 45-64.

(9) Nebel, B. R. Journ. Pom. and Hort. Sci., 1936, **14,** 203-4.

(10) Lewis, C. I. and Vincent, C. C. Oregon Sta. Bull. **104,** 1909.

(11) Crow, J. W. Proc. Amer. Soc. Hort. Sci., 1913, 153-5.

STUDIES IN THE NON-SETTING OF PEARS

II. THE EFFECT OF WEATHER CONDITIONS*

By D. N. SRIVASTAVA

INTRODUCTION.

In 1932 it was decided to begin a concerted attack on the problem of Non-setting of pear blossom (7).

It is now generally accepted that certain pears, like Doyenne du Comice, may blossom year after year yet fail to set any satisfactory proportion of their fruit. It is obvious that certain weather conditions, such as severe frost and rain during the blossoming season, affect the setting of nearly all the varieties of fruit, and there is a well established tradition that most pear varieties are not only adversely affected by such factors but that they need particularly favourable meteorological conditions in order to set an adequate crop regularly. The facts that certain districts with a mild climate have become associated with pear growing, and that pears may be grown successfully on walls and under certain constructed shelters, all suggested that more exact data on the actual effect of meteorological conditions might shed light on the problem.

During a two years' stay at this Station the present writer had an opportunity to develop, expand, and repeat certain of the previous investigations (7), and it was decided to make an intensive study of blossom setting in 1936 and 1937, and on the direct and the indirect effect of artificial shelter.

Observations upon the incidence of the dropping of the young fruits and the effects of certain cultural practices upon this phenomenon have already been published (14).

Such a study naturally led to the question of fertilization of the flower; and although much work has already been done in investigating cross pollination of pear varieties, self-sterility, etc., it was thought desirable to study in detail some of the flower characters of certain well-known varieties, some of which produce heavy, others light crops, in an endeavour to find out whether there were any inherent characters in the sexual parts, which *per se* would obstruct the normal fertilization of the flowers. Investigations were also made to determine whether there is any truth in the popular idea of direct relationship between " strength " or " boldness " of blossom and attractiveness to insects. The results of these intensive blossom studies are reported in a separate paper (15).

These studies have been carried out with four varieties of pears on quince rootstocks. Of these Conference is a " free cropping " variety while Doyenne du Comice, Beurré Hardy and Pitmaston Duchess are generally considered " shy cropping ".

* This article, together with Parts I and III, comprise a Thesis approved for the Degree of Doctor of Philosophy in the University of London.

The author wishes to express his gratitude to the Director and members of the Staff at the East Malling Research Station for their assistance during his two years' stay at the Station.

(1) Climate.

Most authors, to enumerate but a few—Hedrick (10), Dorsey (4), Boyd and Latimer (2)—have emphasized the importance of the weather prevailing at the blooming period. Rain, cold winds, lack of sunshine, and frost at blossoming time are all important factors in limiting the set. These may directly affect the setting of blossom, (1) by delaying the opening of anthers and maturity of stigmas, (2) by washing the pollen and diluting the secretion on the stigmas of the flowers already open, (3) by checking pollen tube growth of flowers already pollinated, (4) by damaging the flowers mechanically (effect of wind) or (5) by actually killing the flowers (effect of frost); or indirectly by limiting the activity of insects and bees which are the main carriers of pollen from flower to flower.

There is no doubt that the set of fruit is largely dependent on the weather at blossoming time. This does not necessarily mean that a high initial percentage set would also mature a heavy crop, for a late frost, such as that in May 1935, and strong winds in early autumn may have devastating effects and greatly thin the fruits.

Not only are the weather conditions during the whole of the growing season important, but as shown by Lees (11), the weather during the previous summer may also have an important effect in determining the future crop.

Hence the records of rainfall, sunshine, wind and frost (as taken by the Research Station) from March to September inclusive, have been correlated with the crops of three varieties of pears in 1936, and from March to July with the set of fruit obtained in one variety in 1937. Two of these varieties did not bear any blossom in 1937, hence the earlier records of crop taken at the Research Station for these varieties from 1934 to 1937 have also been examined in relation to the weather conditions prevailing in those years.

Method of observations in 1936.

Three varieties of pears, i.e. Doyenne du Comice, Beurré Hardy and Conference, were selected, as the former two are considered in England to be shy cropping varieties, while Conference is free cropping. Nine fifteen-year-old trees of each variety, three each on quince rootstocks A, B and C, were selected. On each of these trees four sample branches on four sides, i.e. north-east, north-west, south-west and south-east were marked. The method of choosing these branches was to stand a few steps away on one side of the tree, say north-east, and by walking towards the tree with eyes shut one of the twigs was touched, and the branch on which this twig happened to be, was selected. On each of these branches, starting from the tip of the branch, leaving out the one-year-old wood, the fruit buds on forty spurs were counted separately, and a label was tied on the branch beneath the fortieth spur. In this way nearly the whole of the branch was surveyed. In the case of Beurré Hardy, since the branches were longer, records of fruit buds were taken on fifty spurs instead of forty.

On the same branches records of fruit set were taken before " June drop ", after " June drop ", and at maturity. The set at these different stages on each branch was calculated on the number of fruit-buds. A mean set for the four branches on each tree was thus obtained.*

* Wherever the terms " sample branches " and " set of fruits " are used, the above methods have been followed unless otherwise stated.

The mean set for three trees on each of the three stocks for each variety is given in Table I, and the summary of meteorological observations for 1936 from March to September is given in Table II.

Table I.

Mean Number of Fruits set per 100 Fruit-buds for the three varieties of Pears on Various Rootstocks in 1936.

Rootstocks.	Comice.			Hardy.			Conference.		
	Before June Drop.	After June Drop.	At Maturity.	Before June Drop.	After June Drop.	At Maturity.	Before June Drop.	After June Drop.	At Maturity.
Quince A ..	25·8	12·9	11·5	41·0	22·3	13·4	133·4	55·1	38·3
Quince B ..	45·2	12·0	11·0	46·0	25·4	20·5	135·0	61·5	46·2
Quince C ..	39·4	18·2	16·9	48·7	29·2	24·0	115·0	52·8	48·8

Table II.

Summary of Meteorological Observations for 1936.

	Rainfall.			Sunshine.			No. of Ground Frosts.*	Wind (directions and speed).
	Total in inches.	No. of "Rain Days."‡	21 years' average.	Total hours.	Average per day.	21 years' average.		
March ..	1·21	13	1·50	98·9	3·2	119·2	12(7)†	First half North-easterly, later South-easterly—Moderate.
April ..	1·31	9	2·18	113·4	3·8	127·8	14(6)	North-easterly—Moderate.
May ..	0·44	4	1·74	194·3	6·3	196·1	2(0)	do. Gentle to Moderate.
June ..	3·95	21	1·46	202·5	6·8	202·0	0	Mainly North-westerly, later Southerly—Gentle breeze.
July ..	2·80	18	2·18	166·3	5·6	195·3	0	South-westerly—Moderate.
August ..	1·20	9	2·18	161·4	5·2	184·0	0	First and last week North-easterly, rest South-westerly—Gentle.
September	2·34	16	2·13	93·5	3·1	151·1	1(0)	Mainly North to North-easterly—strong breeze.

* Ground frost is 30·4° F. or less.
† Figures in brackets indicate 5 degrees of frost or more.
‡ A "Rain Day" is one on which not less than 0·01 inch of rain is recorded.

Table I shows that the set of Doyenne du Comice and Beurré Hardy are much lower than the set of Conference, at all three stages on all three rootstocks. The final fruit set (i.e. at maturity) of Conference varies from 38·3 to 48·8

on the three stocks, but in the case of Comice it varies from 11·0 to 16·9 only, and in Beurré Hardy from 13·4 to 24. It should be noted here that the stock effect is clearly manifest ; in every case rootstock Quince C has given the highest set. It has already been reported by Hatton (8), (9), that Quince C is the most precocious of these three rootstocks.

The actual crop harvested in 1936 from these varieties of pears was the highest ever picked. This was probably due partly to total failure of crop in the case of Beurré Hardy and Comice and partial failure in the case of Conference as a result of severe frost in May 1935, and partly due to very satisfactory weather conditions throughout 1936 (see Table II). The weather during the blossoming period of these varieties, i.e. during the last week of April and first two weeks of May, was good. Severe frost was absent altogether (the two mild frosts occurring in the first week of May did not do any damage). The sun shone on every day within these three weeks with an average of 5 hours per day, and it was never very cold in the day. Hence the conditions were ideal for the activity of bees and other pollinating insects, which were noticed to be plentiful and actively at work. There was very little rain during this whole period. Despite the scanty rain the moisture meter fixed at a depth of eighteen inches as described elsewhere (13), recorded on an average a pull 7 cm. Hg, indicating thereby that the soil was fairly saturated.

Such optimum conditions during blossoming contributed to an excellent initial set. The weather during the remaining months of the growing season, though not harmful for the crop of 1936, was not entirely satisfactory for fruit-bud formation for 1937. May was a dry month but the rainfall during June, July, and up to the middle of August was frequent and over the average, the month of June exceeding the rainfall records for the previous twenty-one years. Even then the soil in this month was fairly dry at a depth of eighteen inches. The total hours of sunshine for July, August and September were far below their average of twenty-one years.

Observations in 1937.

Beurré Hardy and Doyenne du Comice did not bear fruitbuds in 1937, so records could be taken only on Conference trees. These latter also bore much fewer fruit buds than in 1936. The mean set before June Drop and at maturity for the same trees as used in 1936 are given in Table III.

TABLE III.

MEAN NUMBER OF FRUITS SET PER 100 FRUIT-BUDS ON CONFERENCE, 1937.

Rootstock.	Before June Drop.	At Maturity.
Quince A ..	22·3	2·6
Quince B ..	83·8	20·3
Quince C ..	1·1	0·6

It will be seen that both the initial and the final set are extremely low, except for the trees on Quince B of which one of the three trees had very few fruit-buds and also a very small crop, but the set was rather high, hence the mean set for three trees is comparatively high. On referring to Table IV it will be found that conditions from March to June inclusive were very wet. The total rainfall

figures for these months are much higher than the average of 22 years, while the total hours of sunshine are much below the average except in the month of June. The actual blossoming period of Conference was from the 17th April to 4th May and the weather was not very congenial for insect activity. The first week was rainy with thundery showers and occasional sunshine; during the second week, when the flowers were in full bloom, though sun shone almost every day with an average of 5·4 hours, there were cold northerly winds on two days, while two other days were rather dull.

TABLE IV.

SUMMARY OF METEOROLOGICAL OBSERVATIONS FOR 1937.

	Rainfall.			Sunshine.			No. of Ground Frosts.*	Wind (directions and speed).
	Total in inches.	No. of "Rain Days."‡	22 years' average.	Total hours.	Average per day.	22 years' average.		
March ..	3·26	18	1·49	104·7	3·4	118·3	23(9)†	First half changeable, later North-easterly—Moderate.
April ..	2·47	17	2·14	104·6	3·5	127·2	1(1)	Mainly Northerly—slight breeze.
May ..	2·71	11	1·66	177·0	5·7	196·0	0	North-westerly—slight breeze.
June ..	2·30	12	1·53	201·4	6·7	202·0	0	Changeable, mostly north-westerly—Gentle.
July ..	0·91	8	2·21	127·8	4·1	194·4	0	South-westerly—Gentle.

* Ground frost is 30·4° F. or less.

† Figures in brackets indicate 5 degrees of frost or more.

‡ A "Rain Day" is one on which not less than 0·01 inch of rain is recorded.

Thus insects were not very active on these occasions. Last, though not least, it is important to bear in mind the summer rainfall and previous crop. It is well known that a large crop in one year tends to be followed by a small crop in the following year. Lees (11) has shown that a wet summer and heavy crop in the previous season upsets the internal condition of the tree and so "weak" blossom and poor crop are the results in the following year. These were actually the conditions prevailing in 1936. It will be more readily understood if it is borne in mind that a heavy crop leaves very little food reserves for flower bud formation for the next year and if this be associated with heavy summer rainfall with little sunshine, there would be very little fresh food formation. Under such conditions trees cannot be expected to bear a successional crop.

In the light of the crop failure of 1937 it was considered desirable to examine the crop records of these varieties, from 1934 and onwards. Records of number of fruit-buds were available only for Conference on stocks Quince A and C, while for Beurré Hardy and Doyenne du Comice, only the number and weight of crop had been recorded on these two stocks. The mean number of fruit-buds, and final set and the mean number and weight of crop picked per tree calculated from seven trees of Conference on each of the rootstocks Quince A and C are given in Diagram 1. For Beurré Hardy and

Comice the mean number and weight of crop picked per tree calculated from eight trees each on stock Quince A and C are given in Table V. In both diagram and table, the trees which were recorded in 1936 and 1937 are also included.

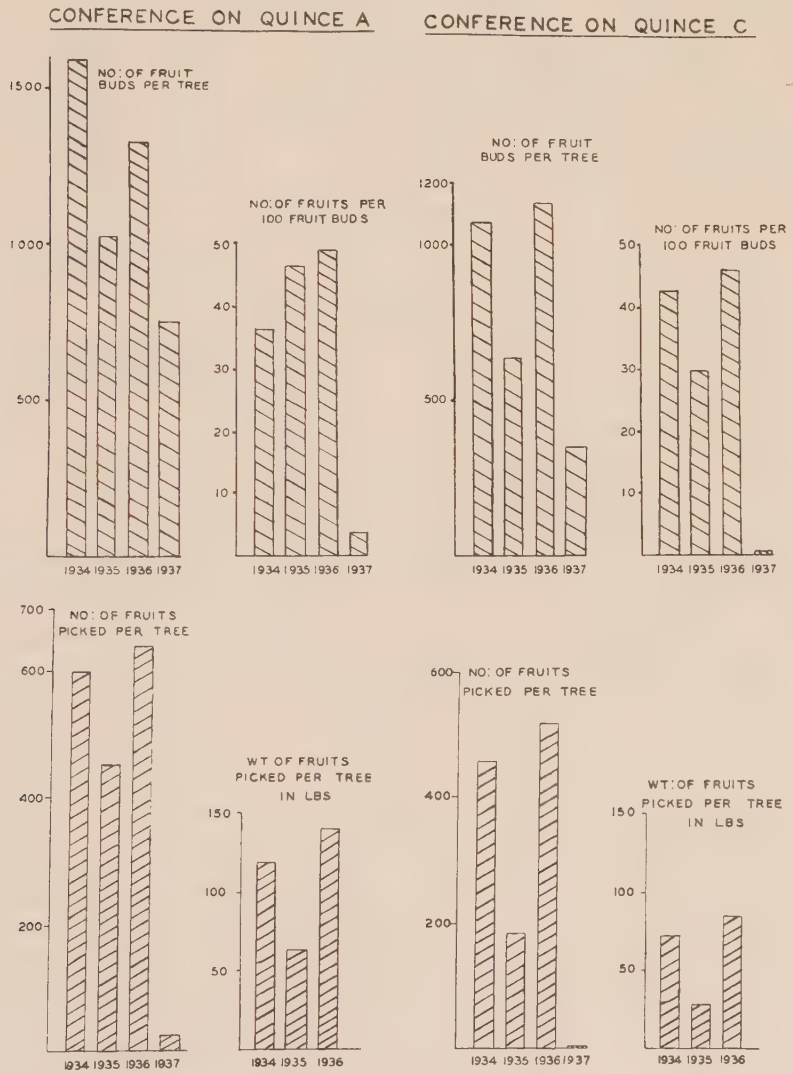

CONFERENCE ON QUINCE A
CONFERENCE ON QUINCE C
NO: OF FRUIT BUDS PER TREE
NO: OF FRUITS PER 100 FRUIT BUDS
NO: OF FRUITS PICKED PER TREE
WT OF FRUITS PICKED PER TREE IN LBS
1934 1935 1936 1937

Diagram 1.

Above—Mean number of fruit-buds per tree and set for 1934-1937.
Below—Number and weight of fruits picked per tree during these years.

From Table V it appears that Comice and Beurré Hardy did not bear any crop in 1935 and 1937. The reasons for 1937 have already been given. In 1935 there was a very severe frost on the night of 16th-17th May which destroyed the whole of Beurré Hardy and Comice crop and not a single fruit was picked. In 1934 the weather was very satisfactory and the crop picked was quite good though not heavy. These particular

TABLE V.

THE NUMBER AND WEIGHT OF CROP PICKED.

Variety and Rootstock.	1934.		1935.	1936.		1937.
	Mean No. per tree.	Wt. (lb.)		No.	Wt. (lb.)	
Comice on Quince A ..	75	22·4	Nil.	203	48·5	Nil.
Comice on Quince C ..	122	30·0	,,	200	50·1	,,
B. Hardy on Quince A ..	139	36·5	,,	655	146·5	,,
B. Hardy on Quince C ..	253	63·2	,,	623	120·6	,,

trees were just beginning to come into full cropping. They had borne very few fruits until 1933. As already said 1936 gave a heavy crop.

On examining Diagram 1 it will be seen that Conference also gave the highest yield in 1936. It gave a very poor crop in 1935, as a result of frost, but the fact that it did bear some crop while others had failed justifies its being called a good cropping variety. Although the number of fruits picked on Quince A was high in 1935, it is reported that they were very irregular and mis-shapen, not completely developed. There was a good crop of this variety in 1934 also, the weather conditions being very suitable. In 1937 the set was extremely low on Quince A, and almost nothing on Quince C.

It will be noted from Diagram 1 that on an average trees on Quince A have given more crop since 1934 than those on Quince C. It has been reported by Hatton (9) that though trees on Quince C are very precocious, they are overtaken in later years by the larger trees on Quince A.

These data therefore show that weather conditions not only at the blossoming time but during the whole of the growing season are important in determining the amount of crop to be finally picked.

(2) SOIL MOISTURE.

A study of weather conditions would be incomplete without considering the moisture content of soil during the critical periods.

Hence in order to find whether moisture deficiency in the soil has any bearing on the shedding of a large proportion of flowers at the blossoming time and partially developed fruits in " June Drop " period and also to give some guidance as to when experimental water injections into the tree might be beneficial, continuous soil moisture records were taken from two positions in 1936 and 1937 by installing two Rogers moisture meters at a depth of eighteen inches. The full data and results of 1936 have been published (13). It was found then, that there was no moisture deficiency at the blossoming period of the varieties of pears studied, but when the " June Drop " generally occurred, i.e. from 12th to 28th of June the soil was getting dry. It was then considered possible that since at this period the leaves and fruits are all expanding, the general " tightening up " of the moisture conditions in the tree may have encouraged the shedding of fruits.

In 1937 it was considered desirable to obtain a comparison between moisture conditions on the bottom and at the top of the sloping portion of the plot, as it was noted that the trees at the bottom of the slope were often more vigorous than at the top. Accordingly the two moisture meters were transferred to new positions in February 1937, and were installed at a depth of eighteen inches at a distance of twenty-four inches from the trunks of two Conference trees on rootstock Quince A. These trees were of

comparable size. Meter A was beside a tree at the top of the slope and Meter B beside a tree at the bottom of the slope.

The daily moisture records from 1st of March to 20th August are given in Diagram 2. It will be noted from Diagram 2 that the two meters showed almost identical " soil moisture tension " throughout the period, proving that soil moisture conditions were not different at the extremities of the slope. During the whole of April and May the " soil moisture tension " was below 10 cm. Hg, and thus the soil at the blossoming period was saturated nearly to its " field capacity ". During the " June Drop " period, which occurred in Conference (other varieties not bearing any fruit) from 9th to 24th of June, the soil moisture tension at eighteen inches rose to a maximum of 19 cm. Hg and then fell again as the result of heavy rain.

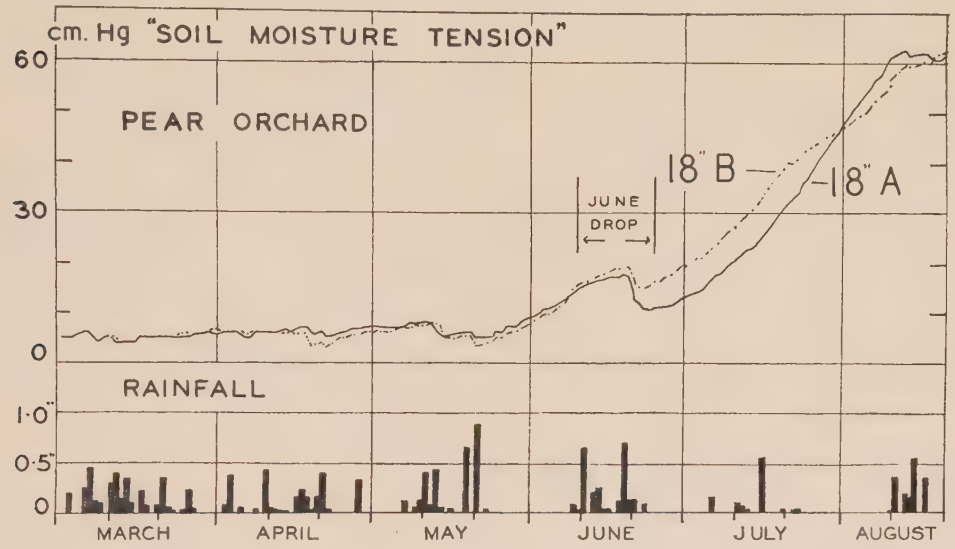


Diagram 2.

Graph showing the " soil moisture tension " at a depth of 18 cm. in two positions from 1st March to 20th August, 1937. Daily rainfall figures shown diagrammatically below the curve.

Thus the June Drop period in 1937 coincided with a rise of soil moisture tension from 10 to 19 cm. Hg whereas in 1936 the June Drop period coincided with a rise of soil moisture tension from 28 to 42 cm. in the case of one meter, and from 30 to 58 cm. in the other. In fact the soil was considerably drier during the " June Drop " in 1936 than in 1937. In both cases the June Drop coincided with a rise in soil moisture tension and the possibility cannot be ruled out that this rise may contribute to the causes of fruit shedding.

(3) Shelter.

It has been a matter of general experience at this Research Station that the same varieties of pear trees growing round the walls of a building, specially on the south side and the portions exposed to the sun on the east and the west sides, although the conditions are not strictly comparable, have borne good crops year after year, while those in the orchard have given a poor set or even sometimes failed to give any crop, if the weather was unsuitable. It has also been noticed that the fruits round the walls, though they

have never been sprayed, have been remarkably free from scab which sometimes causes a fair proportion of the fruits to drop off from the trees in the orchards (12). This suggests that the trees round the walls are in a better position to crop, probably because they are more sheltered from the harmful effects of strong and cold winds and to a certain extent from rain as well ; also because they are more exposed to the sun and are nearer the optimum temperature due to radiation of heat from the walls. Strong winds may reduce the number of blossoms which set fruit, and also tear off fruits which should have normally stayed on the trees till harvesting. From time to time (16), (6), (1) it has been suggested that planting or erecting wind breaks round the plantations would protect the blossoms and greatly reduce the wind-falls. Esbjerg and Dullum (5) say that a plot of apple trees was sheltered on all sides by planting elm trees. They found that trees nearer the shelter yielded much more crop and had much less windfall than the trees farthest away from the shelter.

Bunyard (3) calls the attention of growers to the fact that a great show of pear blossoms for two successive years was " ruined by cold wind and rain from the east ", while a few trees which he grew in the shelter of the walls bore a sufficient crop. He suggests that pear trees should be sheltered in some form, e.g. wired cages.

Hence, to see how far a shelter could be effective, an experiment was carried out in 1936 and repeated in 1937.

Two blocks each consisting of ten sixteen-year-old trees at the two ends of the plot were sheltered in early April 1936 before the buds had opened, by putting up hop-lewing screens to a height of fourteen feet around the trees. The lewing consisted of light coconut matting, six feet wide with meshes half inch square. These were used as they are readily available and can be easily rolled up and replaced in store when not required on the plot. The screens erected on the east end of the plot are illustrated

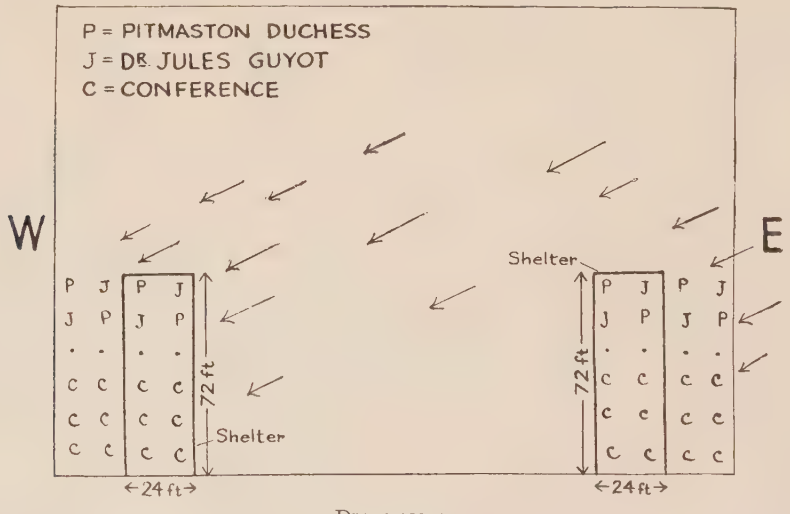


Diagram 3.

Showing the arrangement of the sheltered and unsheltered plots in **1936**. Arrows indicate the direction of the wind during the critical period.

in Fig. 1. These screens were open at the top and two feet towards the bottom was left unsheltered, both in order that the insects would not be prevented from visiting the trees inside the shelter and to allow tractor cultivation inside without dismantling the screens.

The trees sheltered on the west end of the plot consisted of two trees of Pitmaston Duchess, two trees of Dr. Jules Guyot and six trees of Conference all on rootstock Quince A ; the same number of corresponding trees of these varieties were left as control on the west side of the shelter. On the east end also there were the same number of trees inside and outside the shelter, except that all Conference trees were on rootstock Quince B. The control trees in this case were left on the east side of the shelter. The arrangement of the plots in 1936 are given in Diagram 3. Though it was realized that the control trees being so close to the shelters would be affected, yet it was not possible to choose these at any greater distance away from the shelters, since positional difference would have an important effect, and besides it was not known how far the effect of the shelters would extend.

Both inside and outside the shelters at both ends, Six's maximum-and-minimum thermometers were fixed on poles at a height of 5 ft. from the ground, facing north, and daily temperatures were recorded in order to find if there was any difference in the temperatures inside and outside the screens.

On all Conference trees four sample branches were marked as described before and the number recorded of fruit-buds on forty spurs from the tip of each branch. In the case of Pitmaston Duchess, since the trees were very large, four sample branches were marked in the same manner and on each branch one hundred fruit-buds were counted from the tip and a label put beneath the 100th fruit-bud. In the case of Dr. Jules Guyot, two comparable branches on north-east and south-east sides of each tree were marked and all the fruit-buds on those branches were counted. Fruit set was recorded, before and after the " June Drop ", and at maturity, on the same sample branches of these trees, and a mean set at three stages for each tree was obtained. Since the set at the three different stages were similar at each stage, only the final set of the sheltered and unsheltered trees have been compared in Table VI.

Table VI shows that sheltered trees of Conference on the east end of the plot all gave a greater set *and the mean difference is significant,* but on the west end of the plot, there is a great variation in the set, and although the unsheltered trees have on the whole given a higher set than the sheltered trees, the difference is not significant. In the case of Pitmaston Duchess the sheltered trees at both ends have given a significantly higher set. Dr. Jules Guyot on the other hand does not seem to be affected at all by the shelters since at both ends there is very little difference between the set inside and outside the shelter.

In 1932 Bunyard wrote, " Dr. Jules Guyot is the only variety that is fruiting at all freely in the open at Allington." His observations together with the results obtained in this experiment suggest that Dr. Jules Guyot is a variety which does not require sheltering.

The reason the control trees of Conference on the west end gave a slightly better set than the sheltered trees, can be readily explained on referring to their position in Diagram 3 and examining the direction of the wind in Table II. During the two very important months, i.e. April and May, when the trees are in blossom and set small fruitlets the direction of the wind was always north-easterly ; and so the unsheltered trees being on the leeward side of the double screens, were actually more sheltered, and their blossom and fruitlets were more protected from early shedding, than the trees inside the screens which were not protected from the effects of the wind to the same extent. The control trees of Pitmaston Duchess on this end did not give a greater set of fruit than the sheltered trees probably because, as examination of Diagram 3 shows, unlike the control trees of Conference, they were more exposed to north-east winds. The conditions on the east end of the plot were entirely different where

Table VI.

Mean Number of Fruits Picked per 100 Fruit-buds (Blossom Trusses) on Sample Branches of Trees inside and outside the Shelters.

West end.				East end.			
Sheltered.		Not sheltered.		Sheltered.		Not sheltered.	
Tree No.	Mean Set.	Tree No.	Mean Set.	Tree No.	Mean Set.	Tree No.	Mean Set.
Conference on Quince A.				Conference on Quince B.			
1/3	39·0	1/1	46·4	1/39	36·6	1/41	26·8
1/4	38·2	1/2	43·3	1/40	27·0	1/42	19·7
2/3	54·5	2/1	48·2	2/39	50·5	2/41	31·6
2/4	51·9	2/2	74·0	2/40	40·6	2/42	14·8
3/3	80·0	3/1	39·7	3/39	34·9	3/41	31·0
3/4	29·6	3/2	110·2	3/40	55·3	3/42	20·7
Mean=**48·9**		Mean=**60·3**		Mean=**40·8**		Mean=**24·1**	
Pitmaston Duchess on Quince A.							
5/4	10·5	5/2	2·0	5/40	1·5	5/42	0·2
6/3	3·0	6/1	0·25	6/39	4·0	6/41	0·7
Mean=**6·8**		Mean=**1·1**		Mean=**2·8**		Mean=**0·5**	
Dr. Jules Guyot on Quince A.							
5/3	18·9	5/1	36·8	5/39	18·1	5/41	17·5
6/4	31·7	6/2	17·5	6/40	12·4	6/42	21·3
Mean=**25·3**		Mean=**27·2**		Mean=**15·3**		Mean=**19·4**	

the control trees of both varieties were more exposed to the winds and gave a lighter set than the sheltered trees. When the crop had matured and was about to be picked there was another shedding of fruits due to strong north-easterly wind from which the control trees of Conference on the west end were again protected.

These results are highly suggestive that sheltering trees might be an important factor to aid in setting of blossom.

As regards the temperatures inside and outside the shelters, it was found that there was no appreciable difference, the greatest difference being one degree in the minimum temperature in favour of the shelter, and 0·6 degree in the maximum temperature in favour of the unsheltered plot. Such small differences are within the normal error of the thermometers and reading the temperatures, and so are almost negligible.

Having realized that control trees on the west end were selected on the wrong side, the arrangement was reversed in 1937, i.e. the trees sheltered in 1936 were left as controls while the controls of 1936 were sheltered. On the east end, however, the arrangement of the control and sheltered trees was the same as in 1936 (see Diagram 4). Records of fruit-buds were again taken on the same sample branches as in 1936; the trees on stock B on the east end bore very few fruit-buds while there were no fruit-buds on any of Dr. Jules Guyot trees. Daily temperature records inside and outside the shelters were again taken. To find out how far the screens checked or reduced the velocity of

the wind inside the shelter two Patterson's 3-cup anemometers (with cups 5 in. in diameter and the radius of the path of the centre of the cups 6·3 in.) one inside and one outside the shelter on the west end, were fixed on the 30th April at a height of 7 ft. (half-way down the height of the screens). Fig. 2 shows the position of the anemometer and thermometer outside the shelter. Before fixing, the two anemometers were checked by putting them side by side for three days in an open field. After four weeks, i.e. on the

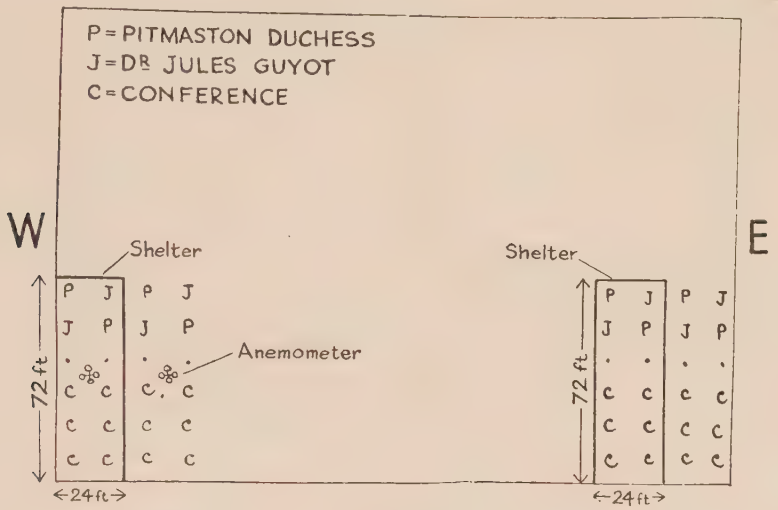


DIAGRAM 4.

Showing the arrangement of the sheltered and unsheltered plots in **1937**. The positions of the two anemometers are also indicated.

27th May, they were transferred to the other end of the plot and fixed in the same corresponding positions inside and outside that shelter. The readings were taken daily in the morning and sometimes twice during the day. The readings at both ends gave similar results, hence only those recorded at the west end are plotted in Diagram 5. The usual interval at which the readings were taken was 24 hours, except for days on which two readings were obtained. In the diagram the velocity and direction of the wind given on any particular date are actually the figures for the preceding 24 hours (or the interval after which the reading was taken). Thus the readings plotted for 30th April show the velocity and direction of the wind for the preceding 24 hours, i.e. from 9 a.m. on the 29th April to 9 a.m. on the 30th April.

Diagram 5 shows that the velocity of the wind inside the shelter is markedly reduced. It is, however, important to note that when the direction of the wind is westerly (including the north-westerly and south-westerly) the velocity inside the screen is more than it is amongst the control trees, e.g. from 4th to 7th May, because as already emphasized in the discussion of data for 1936, under such conditions the control trees are more sheltered and hence the velocity of the wind around these trees was reduced more.

At first it seemed rather surprising to find that the velocity of the wind during the whole period of the experiments never exceeded 2·1 miles an hour, but the anemobiagraph records taken by the Meteorological Section of the Research Station, showed that the windiest day was 22nd May, when the velocity touched a maximum of only 20 miles an hour. The highest velocity, of 2·1 miles per hour, recorded in the pear plantation was also on 22nd May. This great difference in the two records would naturally

occur as the anemometers were placed at a height of 7 ft. only and were amongst the pears, while the vane of the anemobiagraph was at a height of 25 ft. in an open field.

When the experiment was planned it was thought that winds of higher velocity would have to be recorded in view of past experience. Hence anemometers were

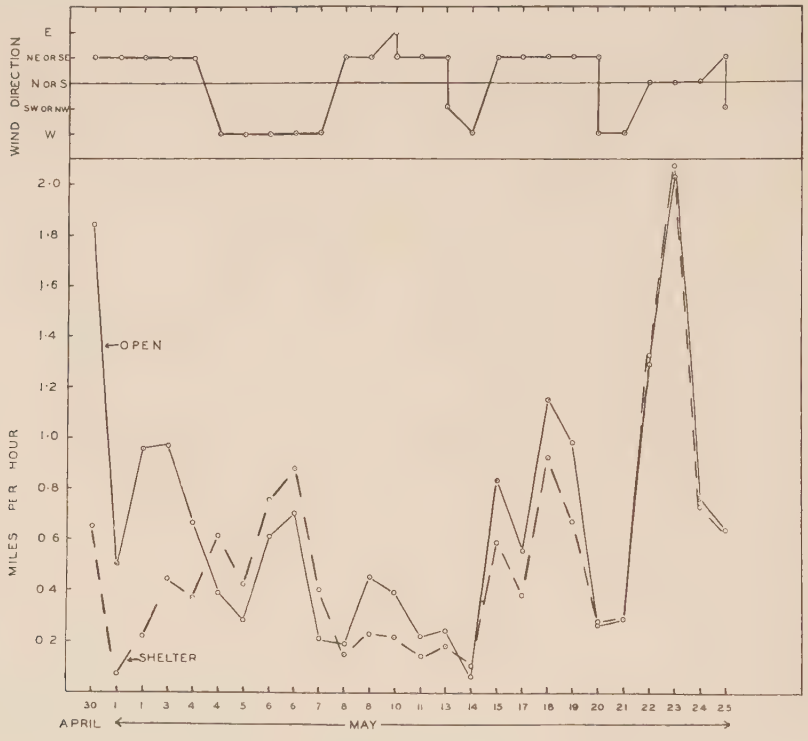


DIAGRAM 5.

Graph showing the velocity of the wind inside and outside the shelter. The direction of the wind is given at the top.

installed which recorded only winds of comparatively high velocity, and these were not supposed to record accurately winds below 5 miles an hour. As it was, they did show a difference between the winds inside and outside the shelter. Furthermore, as has been shown, when the anemobiagraph showed high readings, the anemometers were also relatively high.

When the blossom had set, fruit set records were taken on Conference and Pitmaston Duchess. It was found that there was no set of blossom whatsoever on any of the Pitmaston trees. On Conference there was a bias in favour of the sheltered trees, but, owing to most of the trees having very little blossom and also to unsuitable weather conditions, the variation in set was very great.

From the temperature records of 1937 it was again found that there was not much difference in the temperature inside and outside the shelters. The maximum difference ever obtained was 1·1° in the month of May in favour of the shelter. For reasons already explained these slight differences are almost negligible. It was not surprising to find that there was no great difference in the temperatures, as the sheltered blocks were probably too small to show any great difference, especially as they were open at

the top and the bottom. An impression of increased warmth was often obtained on entering the shelters, but this is evidently rather deceptive, and is apparently due not so much to an increase in air temperature as to a decrease in the force of the wind.

The data given for wind velocity inside and outside the hop-lewing shelters suggest that such shelters are effective wind-breaks and may be used with advantage to obtain a better crop in pears.

(4) Position of Fruit in Relation to Aspect.

On the Dr. Jules Guyot trees, used in the " shelter " trial in 1936, when the first records were taken, i.e. before the " June Drop ", on the sample branches, it was found that there was always a greater set on the branches facing south, than on the ones which were facing north. This phenomenon also existed in a very marked degree in the Pitmaston Duchess trees after the so-called " June Drop " period. It was then found that a greater proportion of the fruits were borne on the south side of the trees. Since the records of set on these trees were based on only one hundred fruit-buds on each of the sample branches, and the set being very low, these positional differences could not be easily discerned. So when the crop was harvested in 1936 from all the trees of Pitmaston Duchess in the " shelter " trial, each tree was divided into two halves—the north half and the south half—and from these halves the fruits were picked separately. The crop records are given in Table VII.

The numbers of fruit set per 100 fruit-buds for Dr. Jules Guyot before " June Drop " and at maturity are given in Table VIII.

Table VII.

The Total Number of Fruits Picked from the two halves of Pitmaston Duchess Trees.

Tree No.	Northern Half.	Southern Half.
5/2	55	61
6/1	8	39
5/4	145	185
6/3	33	87
5/40	14	147
6/39	34	92
5/42	38	130
6/41	41	44
Mean=	46	98

Significant difference (when P=0·01)=36·4.

On statistical analysis it was found that the difference in the number of fruits picked from the two sides of the Pitmaston Duchess trees, and the difference in the initial set on the two sample branches (facing north and south) of Dr. Jules trees were significant. The difference in the final set on the two sides in the latter case is not quite but very nearly significant (P=0·05).

In both varieties examined the greater proportion of the crop was borne on the south side of the tree. Probably owing to the greater amount of sunlight, and the more favourable temperature conditions on the southern side of a tree, the blossoms dry more quickly after rain and the process of fertilization is more rapid. Further, the blossoms

Table VIII.

The Number of Fruits Set per 100 Fruit-buds on Sample Branches of Dr. Jules Guyot.

Tree No.	Before " June Drop ".		At Maturity.	
	N.E.	S.W.	N.E.	S.W.
5/1	64·9	123·6	26·9	46·7
6/2	76·9	85·4	22·3	12·6
5/3	76·4	123·2	17·0	20·8
6/4	58·6	77·9	24·1	39·3
5/39	42·8	64·9	14·9	21·3
6/40	46·4	69·9	7·7	17·0
5/41	36·5	60·4	13·7	21·2
6/42	48·3	55·3	20·2	22·4
Mean=	56·4	82·6	18·4	25·2

Significant difference in the set between the branches facing north and south before " June Drop " = 15·0.

Significant difference in the set on the same branches at maturity = 7·4 (when P=0·05).

on the sunny side are more liable to be visited by insects than those which are on the shaded side. It is also possible that, in the conditions of better sunlight, the leaves function more effectively on the south side. All these factors then may contribute to the setting of a greater proportion of the crop on the south side of a tree, as undoubtedly happened.

General Discussion and Conclusions.

The experiments showed that weather conditions had a definite effect on the set of blossom. The severe frost of May, 1935, destroyed all blossom set, while the wet and rainy conditions throughout the spring and blossoming period in 1937 resulted in a failure of blossom to set. In 1934 and 1936 the weather was satisfactory, and fair and heavy crops were harvested.

Whilst it is true that weather has a direct effect, it indirectly leads to the question as to how this problem is linked with nutrition. The complete failure of crop in 1935 as a result of frost gave an abundant harvest in 1936, as the trees had an extra amount of food reserve. Conditions were just the reverse in 1937.

From continuous soil moisture records it appeared that the " June Drop " period in two years synchronized with the beginning of drying out of the soil, though the conditions were by no means those of a drought in the second year. It is possible, that a general " tightening up " of moisture conditions in the tree at a critical period when all the leaves and fruits are expanding may encourage the shedding of fruits.

The sheltering of trees from strong winds gave indications of increased blossom set. Sunshine appeared to have an important bearing on the setting of blossom, most of the crop being borne on the south side. This again suggested that under better sunlight conditions, more nutrition was available on the south side of a tree than on the shaded side. It seemed likely that on the sunny side the flowers dried more quickly, and had a better chance of being fertilized.

The fact that trees on rootstock Quince C gave the greatest set of blossom goes to support the theory that the problem is one of nutrition.

Summary.

Investigations dealing with the effect of weather conditions on the behaviour of certain poor cropping varieties of pear are described. The varieties studied were Conference, which is generally considered to be a free cropping variety, and Doyenne du Comice, Beurré Hardy and Pitmaston Duchess, which are regarded as poor cropping varieties. The results of the studies were :

(1) Meteorological data, presented for the years 1934-7, showed in general that weather conditions had an important effect on blossom set and also influenced fruit-bud production for the following year. The nature of the effect of abnormal weather conditions is shown to vary with the time at which they occur.

(2) The data presented showed no moisture-deficiency in the soil during the blossoming period at the levels examined, but records taken in two seasons showed a drying out of the soil during the " June Drop " period, although in the second season, 1937, owing to heavy rainfall preceding the " June Drop ", this diminution in the soil moisture was not sufficient to affect the issue.

(3) This experiment, inevitably limited to one season by the total lack of crop in the second year, gave indication that shelter in the form of artificial lewing would facilitate the setting of the blossoms. An apparent contradiction in the result obtained is explained topographically in relation to the prevailing wind at the critical period. There were no noticeable differences in temperature inside and outside the shelter, but there were marked differences in wind velocity as between the sheltered and the unsheltered trees.

(4) The results of one year's records showed that most of the crop on each tree was borne on the south side in both the varieties examined.

Literature Cited.

(1) Bailey, L. H. " The Principles of Fruit Growing." The Macmillan Company, New York, 1926, p. 56.

(2) Boyd, P. L. and Latimer, L. P. " The relation of weather to Pollination of McIntosh Apple." Proc. Amer. Soc. Hort. Sci., 1933, **30,** 12-16.

(3) Bunyard, E. A. " Pear and Shelter." Gard. Chron., 1932, **92,** 181.

(4) Dorsey, M. J. " Relation of Weather to fruitfulness in the Plum." Journ. Agric. Res., 1919, **27,** 103-25.

(5) Esbjerg, Niels and Dullum, N. " Laeets Virkning paa Aebletracer." (The effect of wind-breaks on apple trees.) Statens Forsøgsvirksomhed i Plantekultur Meddelelse, 1936, **243,** p. 4.

(6) Gourley, L. H. " Text book of Pomology." Macmillan Co., Ltd., New York, 1922, pp. 219-24.

(7) N. H. G(rubb), N. B. B(agenal) and H. M. T(ydeman). " Investigations into the non-setting of the blossom of certain varieties of pears." E. Malling Res. Sta. Ann. Rep. for 1931 (1932), 24 ; 1932 (1933), 26 ; 1933 (1934), 30 ; 1934 (1935), 38 ; 1935 (1936), 33 ; 1936 (1937), 37.

(8) Hatton, R. G. " The Behaviour of Certain Pears on Various Quince Rootstocks." Journ. Pom. and Hort. Sci., 1928, **7,** 216-33.

(9) ——— " Rootstocks for Pears." E. Malling Res. Sta. Ann. Rep. for 1934 (1935), 75-86.

(10) Hedrick, U. P. "The relation of weather to the setting of fruit; with blooming data for 866 varieties of fruit." New York Agric. Expt. Sta. Bull., **299,** 1908.

(11) Lees, A. H. "VII. Factors governing fruit-bud formation. The influence of summer rainfall and previous crop on fruiting of apples." Journ. Pom. and Hort. Sci., 1925, **5,** 178-94. Reprinted in Long Ashton Ann. Rep., 1926, 42-59.

(12) Moore, M. H. "Spraying and dusting experiments on the control of Apple Scab (*Venturia inaequalis*) and Apple Mildew (*Podosphaera leucotricha*) at East Malling in 1931-2." Journ. Pom. and Hort. Sci., 1934, **12,** 57-79.

(13) Rogers, W. S. and Srivastava, D. N. "Soil Moisture Studies. II. Moisture Variation in a Pear Orchard." E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 110-13.

(14) Srivastava, D. N. "Studies in the Non-Setting of Pears. Part I. Fruit Drop and the Effect of Cultural Practices." Journ. Pom. and Hort. Sci., 1938, **16,** 39-63.

(15) ——— "Studies in the Non-Setting of Pears. Part III. The Effect of Flower Characters." E. Malling Res. Sta. Ann. Rep. for 1937 (1938), 145-53.

(16) Wilkinson, A. E. "The Apple." Ginn & Co., Boston, U.S.A., 1915, p. 43.

FIG. 1.

Method of sheltering trees by surrounding them with Hop-lewing, showing unsheltered control trees outside.

FIG.
Position of anemometer, thermometer and soil moisture meter amongst the control trees.

STUDIES IN THE NON-SETTING OF PEARS

III. THE EFFECT OF THE FLOWER CHARACTERS

By D. N. SRIVASTAVA

INTRODUCTION.

Certain factors concerned in the failure or partial failure of certain varieties of pear to set a satisfactory proportion of their fruit have already been considered, in relation to cultural practice (14) and to weather conditions (15). In addition the characters of the floral parts, particularly of the sexual organs, have been studied in order to ascertain their relation to fertilization and the subsequent proportion of flowers which set into fruit.

Disregarding " self incompatibility " in any variety, i.e. failure to set fruit with its own pollen when received naturally or by mechanical means, the flower character itself may be a very important factor affecting the setting of fruit. Thus a large " bold " blossom may be liable to attract more insects than a tiny inconspicuous one. A normal complete flower would be better able to set than one which has one of the sexual organs suppressed. In short there may be numerous variations in flower organs affecting the chances of the setting of the flowers. Hence the following characters in relation to set of blossoms in the four varieties under study have been carefully examined.

1. Size of blossom—the size of corolla in a fully opened flower.
2. Sexual organs—the relative length of styles and stamens.
3. Dichogamy—Protandry or Protogyny.

(1) SIZE OF BLOSSOM.

Fruit growers have often remarked that those varieties which have larger blossom are more attractive to insects and hence have greater chances of fertilization and setting. They also say that in a good cropping year the blossoms in general are " strong " while in an " off " year, or in a year when there is a prospect of very little crop, the blossom is generally " weak ".

To find out how far, if at all, there is any truth in such expressions, the size of corolla in two successive years was measured in these varieties to correlate with the set of blossom in these two years.

One tree of each variety on Quince rootstock A was marked. The method of obtaining the mean set of fruits picked was the same as previously described. When the flowers were in full bloom, in 1936, 200 fully developed flowers were selected at random on the sample branches and their diameters were measured. The terminal flower or so-called " King flower " was avoided as its corolla is usually pushed inwards by other flowers around it, and so it could not be measured accurately. (Only 88 flowers of Conference could be measured in the time available.) On each flower two cross measurements were taken, so as to get an average figure for the diameter. In 1937, the same measurements were again taken on the same trees. In the case of Comice and Beurré Hardy, the number of flowers measured was not as large as in the other two varieties, since they bore very few fruit-buds in 1937.

Comparison of Size of Blossom in Two Seasons.

The mean measurements of the diameter of the flowers in each variety for these two years have been summarized and statistically analysed. They are given herewith.

Conference on Quince A.

1936.	Mean of 88 flowers measured ..	=23·7	mm.
	Standard error	= 0·3	,,
1937.	Mean of 200 flowers measured ..	=20·3	,,
	Standard error	= 0·2	,,
	S.E. of difference between the two means	= 0·3	,,
	Significant difference (P=0·05) ..	= 0·7	,,

The difference between the two mean measurements is much more than the significant difference, hence the flowers in 1936 were significantly larger than 1937.

Comice on Quince A.

1936.	Mean of 200 flowers	=22·4	mm.
	Standard error	= 0·2	,,
1937.	Mean of 50 flowers	=21·3	,,
	Standard error	= 0·3	,,
	S.E. of difference between the two means	= 0·3	,,
	Significant difference (P=0·05) ..	= 0·7	,,

Hence the flowers in 1936 were significantly larger.

Pitmaston Duchess on Quince A.

1936.	Mean of 200 flowers measured ..	=27·3	mm.
1937.	Mean of 200 flowers measured ..	=26·9	,,

The actual difference of 0·42 is too small to be significant.

Beurré Hardy on Quince A.

1936.	Mean of 200 flowers measured ..	=19·9	mm.
	Standard error	= 0·1	,,
1937.	Mean of 62 flowers measured ..	=19·4	,,
	Standard error	= 0·2	,,
	S.E. of difference between the two means	= 0·3	,,
	Significant difference (P=0·05) ..	= 0·6	,,

So the difference in size was not significant.

From these data it was found that in 1936 the average size of flowers in Conference and Comice was significantly larger than in 1937. These varieties bore much blossom and had a heavy set of fruits in 1936, while there was very little blossom and no set of fruit at all in 1937 (except in Conference which gave 2·1 set per 100 trusses). In the case of Pitmaston Duchess and Beurré Hardy, the difference in size between 1936 and 1937 was not significant. In fact the blossom produced in both years was very heavy in this variety, while there was very little set in 1936 and none in 1937.

Hence these observations can be summed up in the following way :

1936. Year of much blossom and heavy set—flowers large.
1937. Year of little blossom and no set—flowers smaller.

Comparison of Varieties.

The different sizes of flowers in the four varieties have been compared in relation to their " set " in 1936. In Table I the mean size of flowers and set for each variety is given.

TABLE I.

THE MEAN DIAMETER OF FLOWERS AND FRUITS SET PER 100 TRUSSES.

Variety.	Mean diameter of flowers.	Fruits set per 100 Trusses.*
Pitmaston Duchess	27·3 mm.	0·25
Conference	23·7 ,,	34·8
Comice	22·4 ,,	11·9
Beurré Hardy ..	19·9 ,,	14·5

* Set calculated per 100 fruit-buds and not per 100 flowers.

This Table shows that Pitmaston Duchess has the largest flower, and so according to popular ideas it should have the highest set of fruits. This is not so ; Conference which comes next in size has the highest percentage set. This table also suggests that Beurré Hardy has the smallest flower, but actually it is not so ; the individual flowers of Beurré Hardy are actually much larger than Comice, but the corolla being cup-shaped or cylindrical measures less. In fact, Comice has the smallest flowers, but the corolla opens flat and hence the measurement of diameter is so much more than Beurré Hardy.

From these observations it is clear that the variety having the largest blossom does not necessarily give the highest set. It suggests that the size of blossom as between different varieties appears to have no relation to set of blossom in those varieties.

As to why within the same variety the blossom is, so to say, " weaker " in an " off " year, it seems reasonable to suggest that it is due to nutritional deficiency. After a heavy crop the food reserves in a tree are exhausted and since fruit-bud differentiation takes place within the same year, the blossom produced in the following year would naturally be " weaker ".

(2) SEXUAL ORGANS.

It is generally regarded that Conference is not only self fertile, but is often parthenocarpic, and the other three varieties, Comice, Beurré Hardy and Pitmaston Duchess, are either self sterile or only partially self fertile (2, 6, 12). It was thought worth while to make a detailed description of the sexual organs to see whether this might be a contributing factor both to self sterility and to hindering cross pollination in the shy cropping varieties.

For automatic self fertilization of pistils the stigmas should be on a level with, or below, the pollen-bearing anthers. Hatton (5) has shown that mainly those flowers " run off " in black currants, whose styles are longer than the stamens. Mr. Lawrence Cook in correspondence says that the majority of pears of French origin have the stigmas raised well above the anthers and hence so many of them are only partially self fertile. Crane and Lawrence (2) have mentioned the same factor affecting self fertilization in fruits in general. Flowers in these four varieties were examined and the relative position of stigmas and anthers was determined. Two flowers of each variety were photographed after fixing them to pins in a horizontal position (see Fig. 1). Durondeau and Souvenir du Congres have also been included in this figure in order to have a comparison with

these two outstanding varieties which have stigmas well above the pollen masses, though they are by no means poor cropping varieties. The flower on the left in each variety shows the condition of a flower which has freshly opened while the one on the right shows a flower which has completed its development. It will be seen from the figure, that when the flower opens its stamens are not fully expanded, and so the relative position of stigmas and anthers cannot be rightly estimated then. It is when the flower reaches its so-called " full bloom " period, i.e. when all the parts are normally expanded and the sexual organs are mature, that the relative position of stigmas and anthers should be determined.

The following facts, for each of these varieties, were ascertained after careful examination of a sufficient number of flowers taken at random.

Conference. The styles are longer than the stamens, but when the flower opens they are bent and so the stigmas actually touch the anthers, and receive pollen.

Beurré Hardy. The styles are a little longer than stamens and the stigmas are placed above the pollen masses from the very beginning.

Comice. The styles are shorter than the stamens, hence the stigmas are in a position to receive pollen from the anthers above them.

Pitmaston Duchess. The stamens and the styles are of the same length and so are in a suitable position to self the flower.

In the last two varieties at any rate self sterility cannot be due to the relative position of anthers and stigmas provided they mature at the same time. The relative position of these organs in Beurré Hardy might account in part for its poor setting, if this variety were self fertile in other respects ; whilst the very advantageous position of these organs in Conference might well account for Conference being self fertile. It was therefore decided to compare the time when anthers and stigmas matured in these four varieties.

(3) Dichogamy.

For a variety to be self fertile one essential is that pollen and stigmas should mature at the same time ; by this is meant that when the pollen grains are shed from the anthers the stigmas should be receptive. If, however, the pollen matures first and the stigmas mature after several days, or vice versa, the flowers would not be fertilized and sterility would be the result, unless the flowers are pollinated, either artificially by hand or naturally by insects, with pollen of some other variety which matures at the same time. Hence this character has been carefully examined in the free cropping variety, and in the three shy croppers to see whether this might be an additional reason for self sterility therein.

One tree of each variety was taken for these observations. Before the blossom was open four random trusses on four sides of each tree were selected. On the day the first flowers opened on these trusses they were labelled with small tags bearing the date of opening, and so on every following day, as the flowers opened they were labelled. On the day of opening, a few flowers were removed from the marked trusses and immediately brought to the laboratory for examination under a binocular microscope. This procedure of severing flowers from trusses was adopted since from earlier observations on potted trees in the glass-house, where the trees came into bloom much earlier than trees growing outside, it was found impossible to say from a mere examination with a hand lens whether the stigmas were receptive or not. In several cases, when by such examination a flower would be declared as " stigma dry ", the stigmas were found to be distinctly

moist with secretion, when seen under a very much higher magnification of the binocular microscope. Therefore the examination of the flowers was carried on, in a more comprehensive manner as follows.

Samples of these flowers were taken one day after opening, two days after, and so on, until it was found that pollen was no longer present, and the stigmas were dry. Since these examinations were carried on every day during the blooming period, a fairly representative sample of blossom opening on different dates was obtained to give a correct conception of the maturity of pollen and stigma. For example, a flower which opened on the 16th April and which was examined on the 18th, would be put under the heading of observations on flowers " two days after opening ", and so would be a flower opening on the 21st April and examined on the 23rd April. The examination of flowers in this manner throughout the whole blossoming period of the varieties gave a complete history of this factor. As an example observations for Conference are given in Table II.

TABLE II.

OBSERVATIONS FOR CONFERENCE.

Days.	No. of flowers.	Condition of stigmas.	Condition of anthers and pollen.
Day of opening.	A. (19.4.37)*	Stigmas not receptive.	Most anthers dehisced.
After 1 day.	A. (20-21.4.37)	Stigmas just turning moist, good secretion at the bases of styles.	All anthers dehisced.
	B. (22-23.4.37)	Stigmas not receptive.	ditto.
After 2 days.	A. (22-24.4.37)	Stigmas receptive.†	Anthers full of pollen.
	B. ditto.	Stigmas turning receptive.	ditto.
	C. ditto.	ditto.	ditto.
After 3 days.	A. (22-25.4.37)	Stigmas very receptive (slightly brown in colour).	ditto.
	B. ditto.	ditto.	ditto.
	C. (25-28.4.37)	ditto.	ditto.
After 4 days.	A. (19-23.4.37)	Stigmas turning receptive, slightly brownish.†	ditto.
	B. (21-25.4.37)	Stigmas very receptive, slightly brown.	ditto.
	C. ditto.	ditto.	ditto.
	D. ditto.	ditto.	ditto.
After 5 days.	A. (19-24.4.37)	Stigmas receptive.	Anthers nearly empty, but some pollen present.
	B. (22-27.4.37)	Stigmas very receptive.	ditto.
	C. ditto.	ditto.	ditto.
After 6 days.	A. (22-28.4.37)	Stigmas drying.	Anthers empty, pollen no longer present.
	B. ditto.	ditto.	ditto.
After 8 days.	A. (23.4-1.5.37)	Stigmas dry.	Pollen absent.

* Dates in brackets.
† Flowers checked or hastened in maturity due to weather conditions.

In this Table there are some flowers (marked with daggers) which do not conform to others in the same column, because after opening they were either checked or matured

too early due to weather conditions. For example, it will be found in the flower (A) under observations for " four days after opening " that the stigmas were not yet fully receptive though four days had elapsed since the flowers had opened. This was due to a heavy rain on the next day after its opening, i.e. the 20th April, and so the blossom was checked. But in flower (A) under observations for " two days after opening " it will be found that its stigmas had become receptive within two days, because from the day it opened there were two warm and fairly sunny days, and so the maturity of the stigmas was hastened.

Hence it is very important to bear in mind that the weather during blossoming time is the main factor controlling the maturity of pollen and stigmas. A long cool spell or dull rainy weather checks the maturity of these essential organs, while continuous hot and sunny days hasten the full cycle.

The following facts, for each of these varieties, were ascertained :

Conference. Before the flower is fully open most of the anthers have dehisced ; the stigmas generally become receptive two days after opening and remain so for four days. During this period pollen is also available. After this, pollen is no longer present and the stigmas dry up. Although this variety is protandrous, pollen is available during the full period of the receptive condition of the stigmas, hence self fertilization can be secured provided the variety is self fertile in other respects.

Beurré Hardy. Neither anthers nor stigmas mature until four days after the opening of blossom. They remain mature for three days, after which pollen is no longer present and stigmas become dry. Thus pollen and stigmas mature at the same time and both pass this stage at the same time.

Doyenne du Comice. Before the flower is fully open most of the anthers have dehisced, but generally the stigmas do not become receptive until two to three days after opening and remain receptive for a very short period, i.e. for two days at the most, after which they dry and pollen also is no longer available. It is a markedly protandrous variety like Conference.

Pitmaston Duchess. The anthers start dehiscing one day after the opening of the flowers. The stigmas, however, mature three days after opening and remain receptive for a very long period, i.e. for six to seven days. The pollen in this variety is available for only the earlier part of the receptive period of the stigmas, as the pollen becomes scanty by the third day of this period.

Thus the study of dichogamy has not only shown that all the factors for self fertility in Conference are favourable but it has shown by contrast that the length of period the blossoming, so to say, " hangs about " before it is available for cross pollination in Beurré Hardy, and the very short period in which stigmas are receptive in Comice, may account for these varieties being not cross pollinated and thus setting poor crops. Pitmaston Duchess possesses factors favourable for self fertility but, being a triploid, most of its pollen is sterile and is incapable of being self fertile.

(4) Pollen Studies.

Finally in order to get a complete picture of the sex organs of these varieties pollen germination tests in artificial culture were made in 1937, the media used being different concentrations of sugar solutions. Pollen germination tests have been made by many workers with various species of fruits.

Thus Sandsten (13) used 3 per cent. sugar solution for apples and plums, Namikawa (11) 10 per cent. for apples, Florin (4) 10 per cent. for apples and pears, Beaumont

and Knight (1) 5 per cent. sugar solution and 1 per cent. gelatine for apples. For pears, Tufts and Philp (16) used 12 per cent. sugar solution, Emil Johansson (7) 20 per cent., while Kobel (8) suggests 15 to 20 per cent. Cummings and others (3) used 1·5 per cent. agar solution with 12 to 14 per cent. solution. Moffett (10) used, 5, 10, 15, etc. up to 30 per cent. solutions, and quotes several other authors who have used $2\frac{1}{2}$, 10, 15 and 20 per cent. solutions. Thus it seems that there is a wide range of concentration for the pollen of any given species of fruit.

Pollen from Beurré Hardy, Comice, Conference and Pitmaston Duchess were used. Preliminary trials were made in 1936 in hanging drops of 3, 5, 8, 10 and 15 per cent. sugar solutions using glass rings on slides as moisture chambers. These cultures were put in the laboratory at ordinary room temperature. The results were very unsatisfactory, as the pollen grains did not germinate.

In 1937 the experiment was repeated. Flowers of each variety were collected separately as the anthers matured. 20 c.c. of sugar solutions of strengths 5, 10, 15, 20, 25, 30, 35, and 40 per cent. were made in small tubes and each solution was divided into four smaller tubes. Into each of these smaller tubes two flowers of each variety were dipped and shaken. The flowers were taken out and the tubes were shaken more vigorously. In this way a suspension of pollen grains of each variety in different concentrations of sugar solutions was obtained. Special glass slides were used in which three circles each of 15 mm. diameter were scratched by means of a diamond.

From each of these suspensions the same amount of solution, i.e. 0·05 c.c., was drawn by means of a fine capillary tube, and spread in each of the three circles. Thus there were three replicates of each variety on the same slide for each particular solution. The slides were then labelled and put in moist-chambers (large petri dishes 9 in. diameter) containing a few c.c. of water to maintain a moist atmosphere. These moist-chambers were then put in an incubator at a temperature of 20° C. in order to give identical conditions for these cultures, so as to have a fair comparison of the viability of pollen of four varieties under study. At intervals of twelve hours the slides were taken out and examined under a microscope. The germination percentage from the pollen grains in each of these circles was ultimately determined after twenty-four hours, there being no further germination after this period, and thus an average for each slide was obtained.

The germination percentage of the four varieties in different sugar solutions is given in Table III.

Table III.

Pollen Germination per cent.

Variety.	5% sucrose solution.	10% sucrose solution.	15% sucrose solution.	20% sucrose solution.	25% sucrose solution.	30% sucrose solution.	35% sucrose solution.	40% sucrose solution.
Beurré Hardy	0	0	b*	25	23	40	0	P†
Doyenne du Comice ..	15	2(b)	14	10	17	19	26	38
Conference	10	0	20	34	21	0	13	25
Pitmaston	0	8	15	2	0	2	2	3

b*=pollen burst.
P†=pollen plasmolysed.

From this table it would appear that the same strength of sugar solution is not suitable for all varieties of pear. The germination percentage on the whole is not so high as reported by other workers for pears and other fruits, but Tufts and Philp (16)

say, " Pear pollen on the average does not give as high germination as some of the other fruits." Moffett (10) says, " The results of pollen germination in pear varieties show considerable divergences. Not only do the results of different investigators differ widely for the same variety, but it is found that a repetition of the germination test, using pollen from the same tree in the same sugar solution, may give different results." The maximum germination in any solution for Beurré Hardy, Comice, and Conference was 40, 38 and 34 respectively. These varieties are diploids, while Pitmaston Duchess is a triploid (9), (2). The maximum germination obtained with Pitmaston pollen was only 15, and much of its pollen was shrivelled and of very irregular size. These results confirm the findings of other workers that diploid varieties had a much higher percentage of pollen germination than triploid ones.

The fact that the percentage of viable pollen grains in the self-sterile varieties Beurré Hardy and Comice was slightly higher than in the self fertile variety Conference, confirms the generally accepted idea that the general failure of these two varieties to set their blossom must be due to some reason unconnected with the viability of their own pollen grains.

In the case of Pitmaston Duchess with its low percentage of pollen germination, it is clear that even if conditions were suitable for self pollination the process would remain incomplete on account of the low viability of pollen.

Since Mr. H. M. Tydeman, the plant breeder of the Research Station, was already conducting self and cross pollination investigations with these three varieties, the present writer did not carry this study any farther. His experiments (yet unpublished) confirm that when the three shy cropping varieties were " selfed " they failed to set.

Discussion.

There seems to be no scientific foundation for the popular idea, that a variety with bold blossom is more attractive to insects, and is thus likely to set better than varieties with smaller blossoms. But it is evident that in any variety the blossom is large or " strong " in the year of heavy crop, whilst it is small or " weak " in a year of poor setting, which again points out how it is related to nutrition.

The relative position of anthers and stigmas, and the complete and incomplete forms of dichogamy in the varieties studied, have shown how conditions are favourable in the case of Conference for selfing, by the peculiar bending over of the styles in the early stage of the flower. These studies have also shown how much the maturity of the flower in Beurré Hardy is delayed, and thus chances for its cross pollination are lessened. In Comice the period of receptivity of stigmas is so short that it is not unlikely that it is left unpollinated. Conditions were ideal for Pitmaston Duchess to be self fertile but, being a triploid, most of its pollen was sterile and so the process could not be complete. The pollen grains of Beurré Hardy and Comice were as viable as those of Conference and so their poor setting characteristics could not be due to defective pollen.

Summary.

1. An investigation has been made on the relation between flower characters and the set in certain pear varieties. These varieties were Conference, which is generally considered to be a free cropping variety, and Comice, Beurré Hardy, and Pitmaston Duchess, which are regarded as poor cropping varieties.

2. The size of blossom as between different varieties did not seem to have any relation to set of blossom, but within any one variety in the year of heavy set the blossom was large, while in the year of poor set the blossom was smaller.

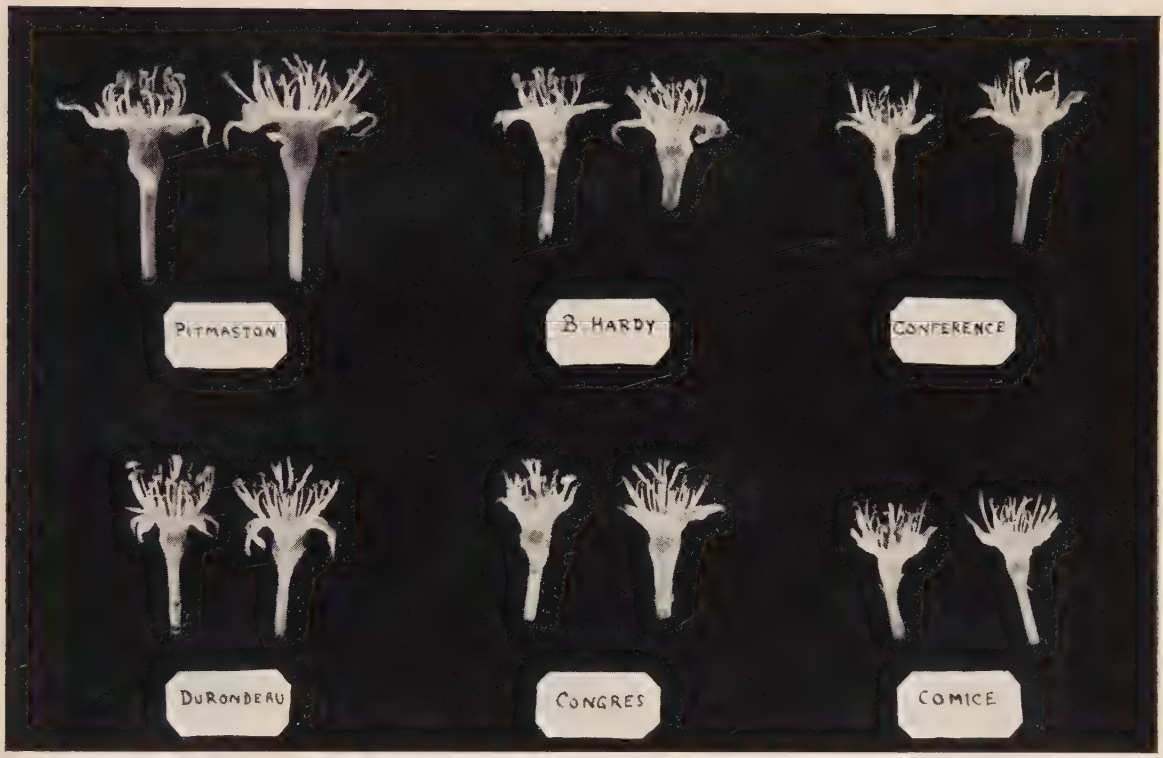


FIG. 1.

Relative length of stamens and styles. The flower on the left in each case shows their relative positions on a freshly opened flower, while the one on the right shows the same organs in a flower which has completed its development. (The petals of the flowers have been removed.)

3. The degree of protandry and the relative position of anthers, and stigmas, varied in the four varieties examined.

4. Conditions were found favourable for the self fertile variety while on the contrary in two self sterile varieties either the receptive period of the stigmas was too short or it was very much delayed. In the case of the third self sterile variety it was found to contain a large proportion of sterile pollen.

Literature Cited.

(1) Beaumont, J. H. and Knight, K. L. "Apple Pollen Germination Studies." Proc. Amer. Soc. Hort. Sci., 1922, **19,** 151-63.

(2) Crane, M. B. and Lawrence, W. J. C. "The Genetics of Garden Plants." Macmillan & Co., Ltd., London, 1934.

(3) Cummings, M. B., Jenkins, E. W. and Dunning, R. G. "Sterility in Pears." Vt. Agric. Expt. Sta. Bull. **408,** 1936.

(4) Florin, R. "Pollen production and incompatibility in apples and pears." Mem. N.Y. Hort. Soc., 1927, **3,** 87-118.

(5) Hatton, R. G. "The 'Running Off' of Black Currants." Journ. Pom. and Hort. Sci., 1921, **2,** 160-98.

(6) Hooper, C. H. "Results of pear pollination trials at Faversham, Kent." Gard. Chron., 1933, **93,** 266.

(7) Johansson, E. "Undersökningar av Pollenets Beskaffenhet hos Fruktsorter." (Studies in pollen quality of fruit trees, with a summary in English. Reprinted from Sverig. Pomol. Foren. Arsskr., No. 1, 1929, as Contr. Swedish Perm. Cttee. Orchard Research, No. 16, Stockholm.

(8) Kobel, F. "Lehrbuch des Obstbaus auf Physiologischer Grundlage." Berlin, 1931, pp. 97-103.

(9) Moffett, A. A. "Cytological studies in cultivated pears." Genetica, 1934, **15,** 511-18.

(10) ——— "Chromosome Number and Pollen Germination in Pears." Journ. Pom. and Hort. Sci., 1934, **12,** 321-6.

(11) Namikawa, I. "Growth of pollen tubes in self-pollinated apple flowers." Bot. Gaz., 1923, **76,** 301-9.

(12) Rawes, A. N. "Pollination in orchards (IX)." Journ. Roy. Hort. Sci., 1933, **58,** 288-95.

(13) Sandsten, E. P. "Some conditions which influence the germination and fertility of pollen." Univ. Wiscon. Agric. Exp. Sta. Res. Bull., **4,** 1909.

(14) Srivastava, D. N. "Studies in the Non-Setting of Pears. Part I. Fruit Drop and the Effect of Cultural Practices." Journ. Pom. and Hort. Sci., 1936, **16,** 39-63.

(15) ——— "Studies in the Non-Setting of Pears. Part II. The Effect of Weather Conditions." E. Malling Res. Sta. Ann. Rep. for 1937 (1938), 128-44.

(16) Tufts, W. P. and Philp, G. L. "Pear Pollination." Univ. of Calif. Agric. Expt. Sta. Bull., **373,** 1925.

STUDIES IN INCOMPATIBILITY OF STOCK AND SCION

II. THE RELATION BETWEEN TIME OF BUDDING AND STOCK-SCION COMPATIBILITY

By R. J. GARNER and D. H. HAMMOND

In a recent paper Chang (2) has shown that the date of budding may affect the bud "take" of an incompatible stock/scion combination, and Amos and others (1) have demonstrated that the percentage of bud-take cannot be depended upon to provide a true indication of incompatibility.

In order to test the effect of the time of inserting buds upon a compatible and incompatible combination of stock and scion it was decided to insert buds of Hale's

TABLE I.

MAIDEN HEIGHT PER TREE IN RELATION TO TIME OF BUDDING.

Date budded 1936.	Stock.	No. of trees.	Height in cm. on four dates in 1937.			
			June 6th.	July 15th.	Aug. 3rd.	Nov. 18th.
24th June	Brompton.	5	30	83	102	118
1st July		5	32	78	97	128
8th July		8	36	89	106	127
15th July		9	30	80	95	110
22nd July		7	38	91	105	125
29th July		7	33	83	103	121
8th August		7	30	81	99	126
12th August		9	19	76	99	130
19th August		7	19	57	79	103
26th August		3	26	63	86	115
Mean per plot			29·3	78·1	97·1	120·3
Coefficient of variability			21·8%	13·6%	8·8%	7·3%
24th June	Myrobolan B.	8	24	46	51	52
1st July		4	28	41	45	46
8th July		6	36	51	54	54
15th July		4	23	43	47	47
22nd July		10	28	43	46	46
29th July		5	36	51	56	56
8th August		6	29	43	46	46
12th August		5	27	47	51	51
19th August		4	21	40	46	46
26th August		6	29	37	44	44
Mean per plot			28·1	44·2	48·6	48·8
Coefficient of variability			17·6%	10·3%	8·5%	8·4%

Early peach into clonal rootstocks of Brompton and Myrobolan B. The first combination was known (4) to be compatible and the second incompatible. One hundred rootstocks of each were planted out in ten plots which were set out at random in two adjacent nursery rows. The numbering of the plots in each row was 3, 2, 5, 7, 8, 1, 4, 9, 10 and 6.

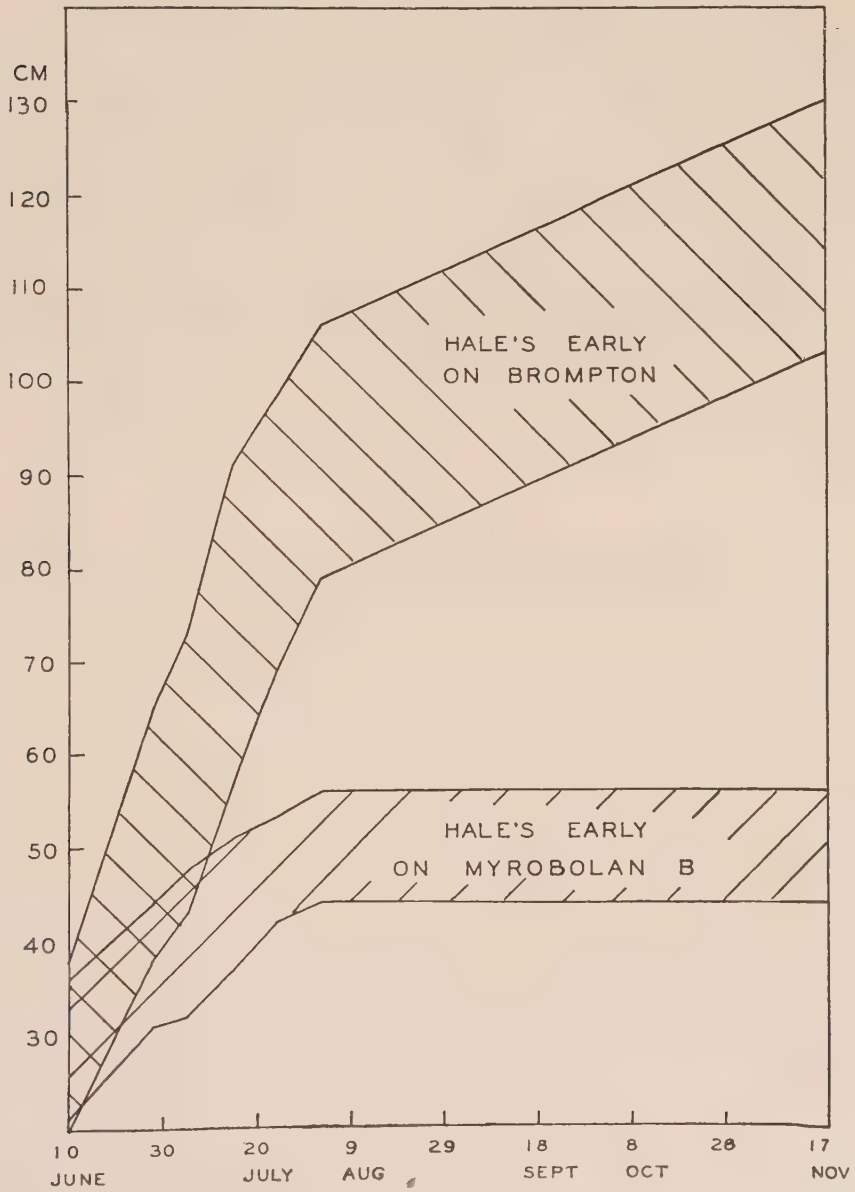


FIG. 1.

Range of shoot growth, 1937, of Hale's Early Peach budded upon the compatible Brompton, and the incompatible Myrobolan B, at ten weekly intervals from June 24th, 1936. Note the consistent behaviour of all plots of trees of each combination.

The No. 1 plots were budded on 24th June, 1936 and the others at weekly intervals, as numbered, until 26th August. All buds were inserted with the wood left in the bud-shield (3).

The maximum length of the shoots produced from the buds during the summer of 1937 was measured on 10th and 28th June ; 5th, 15th and 24th July ; 3rd August, by which time the trees on Myrobolan B had ceased growth ; and finally on 18th November when all the trees were dormant.

The records of height of tree in relation to time of budding are summarized in Table I. The first measurements on 6th June show a considerable variation between plots of the same stock/scion combinations, as is shown by the coefficient of variability, but there is evidently no obvious connection between growth and date of budding. Even if there had been, the different sets even up to a remarkable extent during the season, so that by the time the final measurement is made it is clear that no significant differences exist between them. If the shoot growth, of the trees in each plot, through the season, is graphed, as in Fig. 1, so that the space between the curves for the largest and smallest sets of trees at each measuring is shaded, it will readily be seen that, no matter when the buds were inserted, the compatible and incompatible combinations behaved consistently. Time of budding did not exercise any lasting effect upon the degree of compatibility of an incompatible combination.

Ten trees of each combination were chosen at random and subjected to the strength-at-union test devised by Chang (2). The results of this test are set out in Table II.

Table II.

Strength-at-Union Test of Maiden Peaches on Plum Stocks.

Combination.	Unit.	Mean length total wood growth per tree in cm.	Area cross section 1 in. above union sq. cm.	lb. pull to break.	lb. pull to break per sq. cm. of cross section.
Hale's Early on Brompton	10	923	3·17	118	37·2
Hale's Early on Myrobolan B	10	148	1·44	28	19·4

The Hale's Early/Brompton combination showed rough breaks, which Chang found to be typical of compatible combinations, whilst the Hale's Early/Myrobolan B trees broke cleanly at the union in a manner associated with incompatible combinations.

Summary.

Buds of Hale's Early peach inserted, at weekly intervals during the budding season, into one rootstock compatible and one incompatible with that variety, all gave rise to trees typical of compatible and incompatible stock-scion combinations respectively. Time of budding did not exercise any lasting effect, if any at all, upon stock-scion compatibility.

References.

(1) Amos, J., Hoblyn, T. N., Garner, R. J. and Witt, A. W. "Studies in incompatibility of stock and scion. I. Information accumulated during twenty years of testing fruit tree rootstocks with various scion varieties at East Malling." E. Malling Res. Sta. Ann. Rep. for 1935 (1936), 81-99.

(2) Chang, Wen-Tsai. "Studies in Incompatibility between stock and scion, with special reference to certain deciduous fruit trees." Journ. Pom. and Hort. Sci. (1938), **15,** 267-325.

(3) Garner, R. J. "Studies in nursery technique. Shield-budding—The removal of the wood. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1934 (1935), 123-6.

(4) Witt, A. W. and Garner, R. J. "Peach Stock Trials. A Progress Report." E. Malling Res. Sta. Ann. Rep. for 1928-30. II. Supplement (1931), 22-31.

WEATHER CONDITIONS DURING 1937

By H. C. CHAPELOW and H. M. TYDEMAN

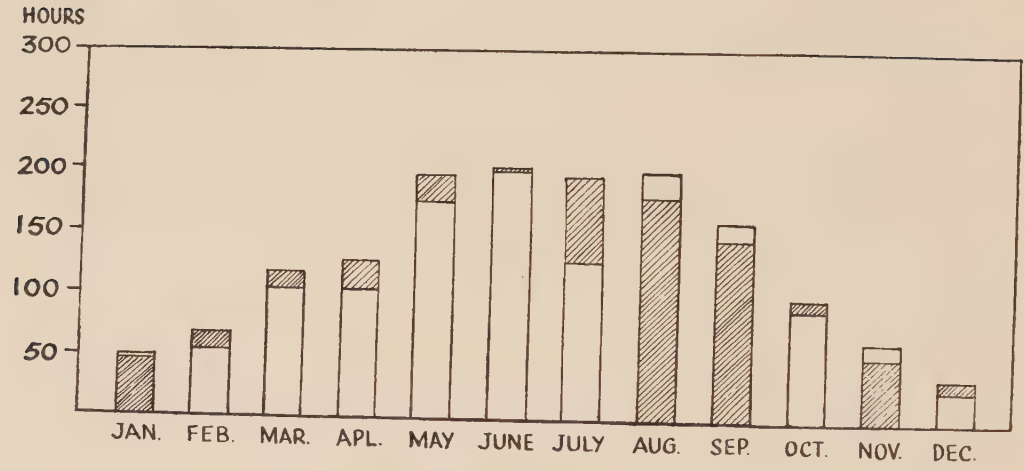
THE past year may be broadly characterized as one of many sudden weather changes. Following a wet autumn, the early months of 1937 were very wet. Between New Year's Day and the end of February, almost ten inches of rain had been recorded and serious flooding was reported in various localities. The early part of March was also very wet with fairly average temperatures. Towards the end of the month, however, conditions became colder and the first and only snowfall of the year was recorded. Cold, rather wintry conditions continued throughout April and the early part of May, with cold biting winds. Severe frosts were, however, conspicuously absent, and all varieties of fruits blossomed under fairly favourable conditions. There followed hot, dry summery weather, and by early August heat-wave conditions were being experienced. In spite of the hot weather following closely upon prolonged rains, severe thunderstorms were not recorded, and only one short thundery period towards the end of June occurred. Throughout the autumn the weather was mild and somewhat wet. December in particular was a very rainy month, precipitation being recorded on 23 days.

The total rainfall for the year was 33·52 inches, and was 7·43 inches in excess of the 23 years' average here. Of the twelve months, nine had a rainfall in excess of the normal, and in January, February, March and December, the difference was particularly marked. Taking the year as a whole, sunshine was slightly deficient. The year's total of 1362·7 hours was 110 hours less than the 23 years' average. The deficiency was, however, well distributed throughout the year and no month could be described as abnormally dull. Temperatures too, did not deviate strikingly from the normal. March, November and December were rather colder than the average and February was somewhat warmer. A noticeable characteristic of the year was the comparative infrequency with which severe frosts were recorded. Between 1st April and 18th October no ground frosts occurred and the total number for the year, 76, was 21 fewer than in 1936.

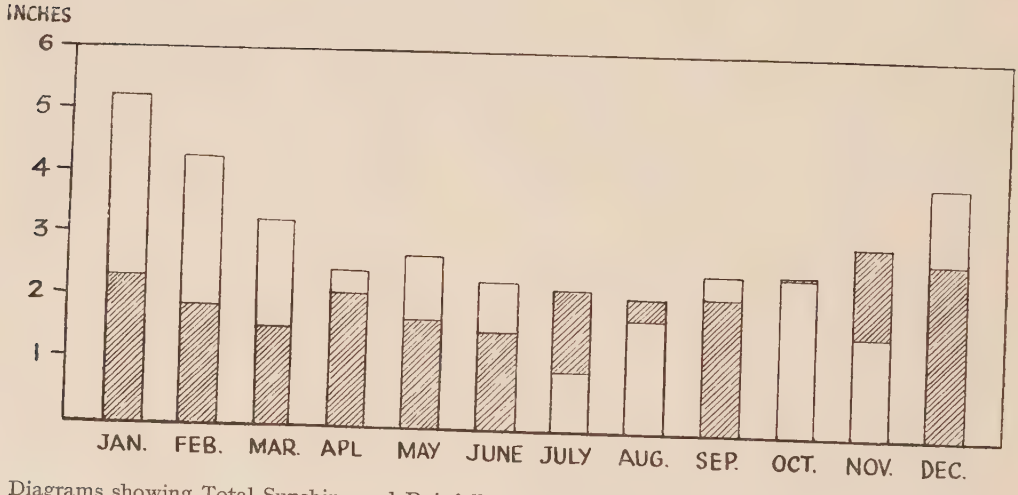
SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1937.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	22 years' average.	Total hours.	Average per day.	22 years' average.	4 inches.	8 inches.	2 feet.
January ..	46·8	35·6	55	27	41·2	13	5·22	0·65	2·39	50·5	1·6	47·3	40·2	40·7	42·2
February ..	48·5	38·1	54	31	43·3	11	4·24	0·63	1·95	56·9	2·0	68·1	40·3	41·1	42·3
March ..	45·5	32·8	56	24	39·0	23	3·26	0·44	1·57	104·7	3·4	117·7	37·8	38·7	40·8
April ..	55·4	41·7	63	33	48·5	1	2·49	0·42	2·16	104·6	3·5	126·2	48·1	47·2	47·4
May ..	62·8	45·8	78	39	54·5	0	2·71	0·87	1·72	177·0	5·7	195·2	54·9	53·4	53·4
June ..	68·0	48·3	81	41	60·0	0	2·30	0·68	1·56	201·4	6·7	202·0	61·8	60·7	61·4
July ..	70·2	53·1	83	47	61·5	0	0·91	0·55	2·15	127·8	4·1	191·5	64·1	63·7	64·0
August ..	73·8	52·7	90	45	63·5	0	1·77	0·56	2·12	199·4	6·4	183·6	64·3	64·3	65·1
September ..	66·2	45·7	75	36	55·5	0	2·47	0·50	2·16	162·2	5·4	149·0	57·0	57·3	60·1
October ..	58·6	43·1	66	31	51·0	1	2·49	0·79	2·50	89·8	2·9	100·0	50·7	51·4	53·8
November ..	48·1	32·7	56	24	40·5	14	1·58	0·62	2·97	65·6	2·2	54·0	40·5	41·7	45·7
December ..	42·2	33·1	55	24	37·5	13	4·08	0·88	2·84	22·8	0·7	37·8	37·0	38·0	39·9

TOTAL SUNSHINE IN HOURS



TOTAL RAINFALL IN INCHES



Diagrams showing Total Sunshine and Rainfall during 1937 as compared with 22 years' average. Shaded portion 22 years' average.

HOPS

A REVIEW OF HOP INVESTIGATIONS AT EAST MALLING

By F. H. BEARD

Introduction.

From its inception East Malling has always been associated with hop investigations. In the original scheme of work drawn up at the opening of the Station, provision was made for the testing of the new seedling hops being raised by Professor E. S. Salmon at Wye. An acre of the 23 acres comprising the Station at that time was reserved for this work, and a few varieties were planted out. The outbreak of war greatly hampered the work and it was not until 1917, when the number of seedlings under trial had increased to 17 that sufficient data had been collected to justify Professor Salmon issuing his first report on the work. Since then reports on the testing of the seedlings have been published annually.

With the extension of the Research Station in 1921 from 23 to 63 acres, the area devoted to hop trials was increased by an additional 6 acres, and at the present time nearly 9 acres are under hops. Prior to 1922 the crop had to be dried on open fire kilns at a neighbouring farm, but with the increased acreage an oast of our own was essential, and the present oast was erected in that year. This was made possible by the joint efforts of the Institute of Brewing and the Kent Branch of the N.F.U., the Ministry of Agriculture making a grant on the pound for pound basis. The oast has two small kilns 16 ft. by 10 ft., fitted with roller hairs, and movable division boards which enable the produce of up to fourteen varieties or plots to be dried separately at one time. Hot air is supplied by a Sirocco Heater and fan.

A greatly extended programme of hop research was adopted in 1926, involving manurial trials in pot cultures, description and trial of commercial varieties, numerous cultural trials and the testing of the best of the seedlings on a larger scale. This programme was to be put into operation gradually as and when land and material was available.

New Varieties.

In all plant breeding work it is necessary to test a very large number of seedlings in order to discover a relatively few promising ones. The hop plant is no exception in this respect, and although the initial selection takes place at Wye, over 500 seedlings have been sent to East Malling for testing since the Station was started, and at the present time some 300 are growing in the gardens.

The following routine is adopted in the testing of the seedlings. Cuttings of those showing promise in the hop nursery at Wye are sent to East Malling where they are propagated and planted out in experimental rows of from 15 to 18 hills. The crop from these rows is picked and dried separately and weighed, the yield per acre and number of bushels of green hops, per cwt. of dried hops is then estimated. Samples of dried hops from over 100 varieties each season are collected in air tight glass jars and sent to Wye for resin analysis by Mr. A. H. Burgess and his assistant. Certain seedlings are pressed

separately in part pockets for use in brewing trials. Records on the susceptibility of the seedlings to disease are also kept, and a report on the incidence of Downy Mildew to date has recently been published (4). It has been found that although there is a very wide range of susceptibility, seedlings of certain parentages are notably more severely attacked. Some crosses have given rise to both very susceptible seedlings and others that are more resistant. The closest correlation between parentage and susceptibility to the disease is shown by rootstock infection; practically all the seedlings that have been attacked in this way have had the Oregon Cluster variety for parent, grand-parent, or great-grand-parent.

Only two seedlings (L21, P43) so far tested have shown real resistance to the disease in all its forms, but unfortunately neither of these has proved particularly acceptable to brewers. Under our conditions the Fuggle has proved very resistant to the disease, though different strains have shown variation in this respect. Attacks on the cones have been largely prevented by routine spraying with Bordeaux mixture.

After the seedlings have undergone a preliminary trial, those proved to be of little merit are grubbed and their place taken by fresh selections from Wye, whilst those showing promise are planted out on a larger scale to provide material for further brewing tests, and enable brewers to get to know the various growths. These plantings also provide a supply of sets for growers wishing to try the new varieties. Up to the present time Brewers' Favourite (OP21), Quality Hop (OO63), Fillpocket (Z62), OI47, L21, P13, and OV7, have been planted out in approximately ½ acre blocks. It was originally intended to establish comparative cropping trials with the best seedlings and commercial varieties, but our inability to grow any other variety than the Fuggle (which is not well suited to our conditions) alongside the seedlings, on account of the mosaic disease, made it necessary to abandon the project for the time being. It is now intended to test any good new seedlings that may in future arise against a named seedling of the same season and type.

As a result of recent joint discussions with Wye it is intended to review thoroughly the merits of the seedlings now growing in the garden, and place a definite limit on the time to be devoted to the preliminary testing of new selections. The seedlings will be grown for five cropping seasons and during that period will be subject to resin analyses, and brewing tests. Only those showing definite promise will be carried on for comparative cropping trials. It is hoped to have not more than 150 (against 300 at present) seedlings undergoing trial at any one time and so release ground for the above trials and for others with commercial varieties.

Commercial Varieties.

A collection of nearly all the commercial varieties was originally planted for comparison with Professor Salmon's seedlings. These rows indicated that some were worthy of more extended trial whilst others could be excluded. Since it was apparent that many commercial stocks were both mixed and mis-named, it was essential to raise clonal races (i.e. vegetatively propagated families from single selected parents) of the principal varieties for experimental work. Systematic descriptions were to have been made with a view to establishing easy methods of identification. The product of cropping trials carried out with the clonal material was to have been available for comparative brewing trials. It was also thought desirable to test different strains of certain varieties.

A start was made with the above work in 1927, but from the beginning it was greatly hampered by the presence of the Mosaic disease in the true Goldings and Golding varieties. However, by 1931 clonal races of thirteen varieties and strains of Fuggles,

Bramlings, etc., had been raised. It was then established that all the new seedlings were carriers of the mosaic disease and that it was impossible to grow susceptible varieties such as Goldings in their vicinity. The large-scale plantings with Goldings had therefore to be abandoned until a separate garden remote from the seedlings could be established. As the Fuggle had proved immune to the disease a trial of three strains was planted out, and one strain has proved to be a rather heavier cropper than the other two.

The varieties Colgate, Tolhurst, Prolific and Meopham were abandoned owing to their being of little economic importance, but small nuclei of other commercial varieties were established in a remote part of the Station for careful roguing for mosaic. Unfortunately mosaic continued to appear, and it was then considered that the Fuggle was probably acting as a carrier after contact with the seedlings. With the Fuggle removed the incidence of the disease has decreased, and is now well under control. The systematic description of the varieties has been to some extent held up by pressure of work in the main garden. The isolated situation of the garden has made pollination from outside sources uncertain and the establishment of mosaic-free males has been a slow process, so that no cone descriptions have yet been possible. Whilst it has been possible to recognize certain varieties (Fuggle, Tolhurst, etc.), on bine and petiole colour, a far more detailed study of the Golding types is needed.

It is now intended to devote more time to this work and to raise clonal material for cropping trials with the Goldings.

Manurial Investigations.

In the light of the valuable information obtained by means of pot cultures on the manuring of fruit trees by Dr. T. Wallace, at Long Ashton, it was felt that similar experiments with hops should give equally useful information.

A sand culture experiment was therefore carried out from 1927 to 1931, and valuable diagnostic characters associated with the omission of certain essential elements were observed. A report on this work has been published (2).

The results obtained from a series of field trials carried out prior to 1928 to test substitutes for dung, various forms of phosphatic manures, and forms and quantities of potash manures, were largely affected by the serious inroads made by mosaic disease on the variety Tutsham. They did yield however certain indications that under our conditions none of the organic manures used gave as good results as dung, and that potash in any form was beneficial (1).

Many of the New Mexican seedlings are extremely vigorous, and therefore possibly do not require such heavy nitrogenous manuring as do the less vigorous types of seedlings and commercial varieties. This point is now being investigated on the seedling OI47, which will receive different amounts of nitrogen in addition to a basic dressing of potash and phosphates.

Cultural Trials.

Owing to the mosaic disease it has been necessary to carry out these trials with the Fuggle and on the large scale plantings of seedlings. The very great range of vigour and type of growth possessed by the latter makes them particularly suitable for this work.

Distance apart of hills.

The most striking result obtained from the series of field manurial trials (1) was the very great increase in the yield per hill in those plots in which the hills were more widely spaced through the death of neighbouring hills. It was considered that this effect of distance between the hills should be further investigated and in 1928 a plot of the

seedling L21 (then considered a good early hop) was planted out for this purpose. The hills were planted at 3 ft., 6 ft., and 9 ft. apart in the rows. In this trial and throughout the hop garden the Butcher system of wirework with 7 ft. alleys is used. The trial was carried on over six cropping seasons and a report has recently been published (3). The yield per hill increased with the increase in distance between the hills, though not sufficiently to counterbalance the effect of fewer hills, hence the yield per acre was increased by closer planting. Close planting is also being tried on Brewers' Favourite (OP21) and P13. In 1934, the first full cropping year with Brewers' Favourite close planting (3 ft. 6 in.) gave an increase of 4 cwt. per acre, but in subsequent years the difference has decreased and was not significant in one season. So far (1 year) P13 has not responded to close planting. This differential response to close planting may be considered as due to the different type of growth of the varieties. Whilst L21 makes short laterals, Brewers' Favourite makes long laterals, the lower ones of which become barren when the hills are close planted. It is possible that a very vigorous variety may respond favourably to very wide planting, and this is now being studied on the seedling OI47.

Number of Bines per String.

In the trial with L21 mentioned above the effect of the number of bines trained up each string was also under investigation. The influence of the number of bines on the yield was only slight, and was at all marked only in the very wide spacing (9 ft.) where 2 and 3 bines were always better than 1 (3). With OV7, a more vigorous variety so far (two seasons) there has been no difference in yield between 1, 2 or 3 bines per string.

This slight effect of the number of bines is of particular practical importance as in some seasons the number of bines in hop gardens may be reduced by attacks of the terminal spike form of Downy Mildew. The results obtained from our experiments indicate that so long as each string is furnished with at least one good bine, little reduction in the yield is likely to take place.

Although distance of planting and number of bines per string do in certain seasons markedly affect the size of cone and hence the appearance of the dried sample, they do not affect the resin content.

Methods of Cutting.

The effect of hard and light cutting is being studied on three strains of Fuggle. So far there has been no difference in cropping, but the lightly cut hills are getting very high in the ground. In the severe spring frost of 1935, the bines from the lightly cut hills being more forward, were more severely frosted.

Quality Hop (OO63) is being utilized for a trial of times of cutting with and without subsequent pulling.

Pulling.

Hard and light pulling is being tested on Brewers' Favourite (OP21) and P13, but although the amount of bine produced is naturally increased by light pulling so far there has been no corresponding increase in the crop. Both these varieties have long laterals, and it is possible that Quality Hop (OO63) now under trial, may show a different response, as it has shorter laterals.

Stopping.

If hop picking machines are used it is desirable that there should not be much "head" on the bines.

Preliminary trials carried out on the Tutsham indicate that stopping the bine during growth greatly affects the formation of heads. This is now being more fully investigated on the seedling OV7.

Pests and Diseases.

The problem of Hop Red Spider control has been under investigation by Dr. A. M. Massee and a brief progress report appeared in 1935 (5). More recently it has been found that 1 per cent. lime-sulphur applied in May or June gives a satisfactory control of Red Spider in the field. It is hoped to continue these investigations in 1938.

Dr. Massee is now conducting preliminary investigations into the possible insect vectors of Hop Mosaic.

The Verticillium Wilt of Hops is being studied by Mr. R. V. Harris in collaboration with Mr. B. S. Furneaux of the South-Eastern Agricultural College and a summary of the results of their investigations to date appears elsewhere in this Report (see p. 257).

Although Verticillium Wilt has never occurred in the Research Station gardens it is a very serious disease in some districts.

Summary.

The results of hop investigations from the inception of the Research Station to the present time are briefly summarized under the headings of New Varieties, Commercial Varieties, Manurial Trials, Cultural Trials, and Pests and Diseases.

The lines on which present work is being carried out are also indicated.

References.

(1) Amos, J. and Hoblyn, T. N. "Manurial Trials with Hops." E. Malling Res. Sta. Ann. Rep. for 1926-7, II. Supplement (May, 1928), 165-71.

(2) Beard, F. H. "Manurial Experiments with Hops in Pot Culture." Journ. Pom. and Hort. Sci. (June, 1932), **10,** 91-105.

(3) ——— "Cultural Trials with Hops. II. The Effect of Distance of Planting and Number of Bines. A Final Report on the Trial with the Seedling L21." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 117-25.

(4) ——— "Observations on the Incidence of Downy Mildew on New Seedling Varieties of Hops at East Malling, 1924-36." Journ. Pom. and Hort. Sci. (Oct., 1937), **15,** 205-25.

(5) Massee, A. M. "Notes on Some Interesting Mites and Insects Observed on Hops and Fruit Trees in 1935." E. Malling Res. Sta. Ann. Rep. for 1935 (May, 1936), 164-70.

PRICES OBTAINED FOR CERTAIN NEW VARIETIES OF HOPS, 1931-1937

By F. H. BEARD

Now that several of the most promising of Professor Salmon's seedlings have been named, and are being grown commercially, we think that our hop growing members may be interesting in the prices obtained for our growths of the named seedlings and for certain unnamed ones that have been grown in bulk.

The Research Station hops, like those of Wye College, are exempt from the provisions of the Marketing Scheme and are therefore not sold through the agency of the Hops Marketing Board. Mr. C. G. Tosswill, of Messrs. Wigan, Richardson & Co., very kindly samples the growths and offers them to interested brewers at what he considers is a fair price.

The seedlings are carriers of the mosaic disease, and cannot be grown near Goldings or Golding varieties, so the only commercial variety available for comparison is the Fuggle. This variety is not well suited to our soil and we do not therefore produce a really first class sample. We think, however, that the figures do give an indication of the relative value of the new varieties. It will be seen that all the named seedlings have consistently realized more than the Fuggle, and most of them give heavier yields than that variety under our conditions. The average yield of 19½ cwt. per acre for Fuggle given in the table is probably rather high. It is based on three years' cropping of a half acre plot of three strains. Various short rows of several strains grown in the garden from time to time have given much lower yields.

Manitoba Seedlings.

Brewers' Gold has fetched the highest prices of all varieties in each season with the exception of 1935 when it suffered from wind damage. Bullion Hop is of similar character but the cones are rather larger and therefore easier to pick, but it is not such a heavy cropper. These varieties possess the American flavour but in recent brewing trials Brewers' Gold has been found suitable for the making of pale ales. Brewers' Gold is being grown by two firms of brewers in this country on an extending acreage. Owing to the fact that both it and Bullion Hop are richer in resins than the American varieties (the richest commercial growths in the world), they are being planted up in Canada and in the United States.

Late Varieties Saleable as English Growths.

The three named seedlings, Brewers' Favourite, Quality Hop and Fillpocket fall into this group. Derived from the American variety Oregon Cluster, they have a higher resin content than existing English varieties, whilst the American aroma is absent or so slight that they are saleable as English growths. All three varieties have consistently realized more than our Fuggle growths. Prior to 1937 the prices obtained for Fillpocket were somewhat lower than those ruling for the others, but this variety was then being grown on land closely overlying the rock which adversely affected both the quality and quantity of the crop. Fillpocket has however given good results over a number of years in the Wye College gardens. Quality Hop ripens at about the same time as the Fuggle, whilst the other two are rather later in season. Quality Hop is also a lighter cropper than the others, but a study of its habit of growth indicates that it might give heavier crops if planted closer than the normal station plant of 7 ft. by 7 ft.

All three varieties are being grown commercially on a slowly extending acreage. The seedling OV7 which has a good analysis was at one time thought to have a commercial future, but further trial has shown it to be unsuitable. Nevertheless, it is interesting to note that in 1933 it realized the top price of £16 10s. per cwt. In most seasons it is far too late in ripening, often having to be picked when not fully ripe, and under East Malling conditions the cones contain too many seeds.

Early Varieties Saleable as English Growths.

Professor E. S. Salmon has informed the writer that it has been found much more difficult to breed early hops of merit, than those of later season. Of the three varieties of this group in the table only one, Early Promise, can be recommended for commercial cultivation. L21 whilst proving very satisfactory from the growers point of view has proved unattractive to brewers, possibly on account of its Tolhurst parentage. P13 makes a most attractive sample and this is reflected in the prices obtained in the seasons 1935-7, but it is a very poor cropper.

New Mexican Seedlings.

These are mostly extremely heavy croppers with a high preservative value. They have a very rank aroma which renders them only suitable for use in a blend, or in brewing stouts. They should not be planted commercially unless the grower knows that he will be able to dispose of a hop of this type.

Cats' Tails and OI47 (to be named shortly) are the best of this class of hop so far tested. The former carries slightly heavier crops and makes a rather better sample when dried, whilst the latter is slightly richer in resins and makes rather less rank growth. Both varieties are however, like most of these hybrids, very strong growers.

Hop Prices 1931-7.

Variety.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	Average yield.
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	cwt. per acre.
Fuggle	6 10	8 0	15 0	8 15	9 0	8 0	8 10	19½ (3)*
Brewers' Gold (C9a) ..	**8 0**	**10 10**	**16 10**	**11 0**	**10 0**	**11 0**	**11 0**	25 (9)
Bullion Hop (Q43) ..				**11 0**			**10 0**	21½ (3)
Brewers'Favourite(Op21)	**7 10**	**9 0**	11 0†	**10 0**	**10 0**	**9 0**	**9 0**	21 (16)
Quality Hop (0063) ..		**9 0**	**16 10**	**9 10**	**9 10**	**9 10**	**9 10**	18 (7)
Fillpocket (Z62) ..	**7 10**	**8 10**				**8 10**	**9 10**	—
Early Promise (X35) ..	**7 10**	**10 0**	**16 10**		**10 5**		**9 0**	18¾ (16)
L21	6 0	6 10	13 10	8 10	8 10	**8 10**		22½ (12)
P13	5 15‡	7 10‡			**10 5**	**10 10**	**10 0**	15 (9)
Cats' Tails (OZ79) ..	**7 0**	**8 10**	14 10		**9 5**	**10 10**	**10 5**	28 (8)
OI47	**7 0**	**8 10**	14 10		**9 5**	**9 0**	**9 10**	26 (8)
OV7	5 15	7 10	**16 10**	**9 0**	8 0	5 10	7 0	25 (9)

* Figures in brackets indicate number of seasons' cropping on which average is calculated.
† Held back until late in season when prices had fallen.
‡ Crop affected by Downy Mildew.

Summary.

Prices obtained during the seasons 1931-7 inclusive are given for the principal new varieties and the Fuggle. Brief notes on the character and season of the new varieties are also included.

STATISTICS AND RECORDS

EXPERIMENTS IN SAMPLING TECHNIQUE.

II. SIZE AND COLOUR OF ALLINGTON PIPPIN 1936 CROP

By T. N. HOBLYN and J. L. EDGAR

In the Report of this Station for 1934, an account was given of an experiment in sampling the crop of Bramley's Seedling apples for size and colour (1). It was then concluded that, with a crop of about eight orchard boxes (320 lb.) to a tree, a single sample of 120 apples (about one box), obtained by selecting at random an equal number of apples from each orchard box containing the crop, was sufficient to give a very fair estimate of the average colour and size of the apples on the whole tree. The coefficients of variability (2) for single samples from individual trees, thus obtained, were 4·9 per cent. for "Colour" and 5·6 per cent. for "Size". This method of sampling was shown to be much superior to the somewhat easier way of taking a single orchard box at random from the crop as it stood beneath the tree. To obtain the same accuracy as with the "mixed" samples, three times the number of apples would have been needed. This was accounted for by variations in colour and size in different parts of the same tree and a tendency of pickers to gather the largest and best coloured fruits first.

In 1936 another bumper crop was harvested and the opportunity thus occurred to extend this study to another variety, Allington Pippin. The crops of eighteen half standard trees, fourteen years old, in an apple rootstock trial, were available for study. These comprised six trees on each of three clonal rootstocks, Malling Nos. XII, XVI and Crab C. All were carrying a full crop, which varied from 132 to 285 lb. per tree. Allington Pippin is a dessert apple of medium size and fairly good colour, as opposed to the large green Bramley's Seedling used in the previous experiment, and it was selected for this reason. Actually, however, the average colour per tree did not work out very much higher than that for the Bramley's Seedling receiving a low nitrogen manurial treatment, which formed part of the earlier study.

In this season it was considered worth while to try rather smaller samples than those previously used. The entire crop from each tree was therefore divided up into samples of forty apples each; the actual number of samples per tree varied from nine to twenty-six, but averaged about seventeen.

The method of selection was the same as that which proved satisfactory in 1934. Thus, an equal number of apples was selected at random from each of the containers into which the crop was harvested, to make up a sample of forty apples, and this process was continued until the whole crop was accounted for. The total number of samples from all trees available for study was 314.

Each of these samples was now graded into seventy-two grades for size and colour. The method used was the same as that now commonly used at this Station, and fully explained elsewhere (1, 3). It may, however, be briefly recalled here. Each sample was first divided into six size grades, grade 1 including the largest apples and grade 6 the smallest. Each of these was then sub-divided into four grades, according to the

amount of surface colour. The greatest amount, designated 1, having over three quarters, and the smallest, designated 4, having up to one-quarter of the surface coloured red. These twenty-four grades were further sub-divided into three for intensity of colour, the colour standards being taken from Ridgway's colour charts.

From these seventy-two sub-divisions the average size and colour figures were computed in the usual way. That is to say, the average size figure was obtained by multiplying the number of apples in each of the six size grades by the grade number, adding, and dividing by forty, the number in the sample. To obtain the appropriate figure for each of the twelve colour grades, the grade number for amount of colour was multiplied by that for intensity, e.g. an apple having from half to three-quarters of its surface coloured (amount grade 2) and of the lowest intensity (3) would be given a colour figure of six. The average colour figure was obtained in the same way as that for size. It will be recalled that the largest and highest coloured fruit have the lowest figure—first grade fruit being usually understood as the best.

TABLE I.

INDIVIDUAL TREE CROPS IN 1936 AND COLOUR AND SIZE FIGURES COMPUTED FROM THE WHOLE CROP OF SIX TREES OF ALLINGTON PIPPIN ON EACH OF THREE ROOTSTOCKS USED IN SAMPLING EXPERIMENT.

	Rootstock No. XII.			No. XVI.			Crab C.		
	Total crop. lb.	Size.	Colour.	Total crop. lb.	Size.	Colour.	Total crop. lb.	Size.	Colour.
	134	3·13	7·87	167	2·82	6·11	229	2·91	6·43
	143	2·85	7·40	153	3·17	5·61	285	3·19	7·56
	228	3·27	6·28	214	3·15	5·68	193	2·85	7·35
	191	3·41	5·57	132	2·42	6·42	197	3·26	6·59
	199	3·47	6·93	206	3·15	6·41	166	3·25	6·01
	235	3·14	7·38	198	3·13	7·34	145	3·37	6·12
Mean	188·3	3·21	6·90	178·3	2·97	6·26	202·5	3·14	6·68

In order to equalize the effect of colour changes throughout the period in which the grading took place, viz. seven days, the trees were dealt with in successive groups of three, one on each of the three rootstocks, the order of the three different trees being varied within the groups. The actual size and colour figures from the whole crop of each individual tree, together with the actual crops in pounds, and the means for each set of six, are shown in Table I.

The average crops of the trees on the three rootstocks vary from 178·3 lb. to 202·5 lb. per tree, but as the difference necessary for significance ($P = \cdot 05$) was 51·7 lb., they cannot be said to have differed significantly in this year. In the same way, none of the size or colour figures were significantly different, the differences necessary for significance being 0·31 and 0·88 respectively.

It may be noted that the average size was about the centre of grade 3, so that the average apple had a diameter about $2\frac{5}{8}$ inches. The average colour figures on analysis showed that most of the fruit were rather under half coloured, with a rather low intensity of the red colour.

When the grading of individual samples was completed, in order to arrive at the most economical sized sample, random lots were drawn from those comprising the crop

of each tree to form samples of increasing size. Thus, firstly a single sample was drawn, then two samples to make a composite sample of eighty apples, next three samples, and so on up to nine samples or 360 apples per tree. This process was repeated once for each sample size ; there were thus two samples of forty apples, two of eighty apples, two of 120 apples and so on. The data were then re-analysed for each new sampling and the results are shown in Table II. This Table shows the mean size and colour figures arrived at for the three rootstocks at each new sampling, and the differences between them which will give a 20 to 1 chance (P = ·05) of significance.

Comparing these averages with those for the entire crop it will be seen that with samples of eighty apples and over there is a very close agreement both in the colour

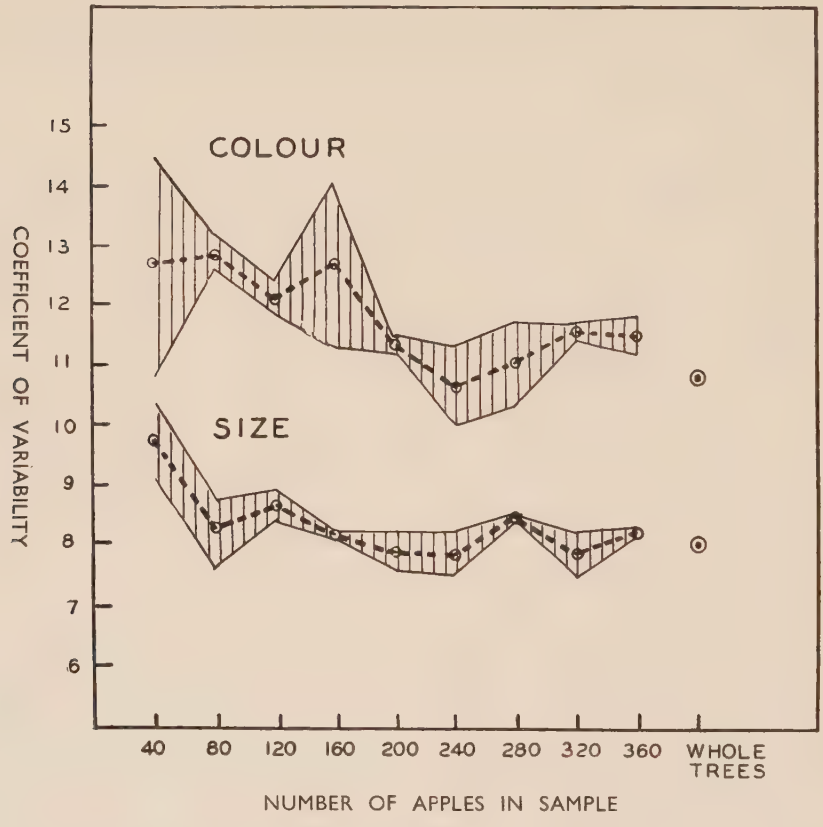


Fig. 1.

Coefficients of Variability obtained for size and colour of individual trees of Allington Pippin with increasing numbers of apples per sample. 1936 crop.

and size figures, and in no case do the samples give a significantly different result from that given by the whole crop. The agreement in size appears rather closer than that for colour.

Table II also gives the coefficients of variability obtained for samples of increasing size and these are illustrated in Fig. 1. These are based upon the variation within the sets of trees on the same rootstock, after any differences between rootstocks have been eliminated. The dotted lines in Fig. 1 connect the means of the duplicate values of the

Table II.

Average Colour and Size Figures obtained and coefficients of Variability for various sized Samples in Allington Pippin Sampling Experiment.

Colour.	No. of Apples in a sample.																		Whole trees.
	40		80		120		160		200		240		280		320		360		
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
Rootstock No.																			
XII.	7·00	7·12	7·02	6·89	6·67	7·03	6·79	6·82	6·78	6·90	6·87	6·99	7·00	6·75	6·93	6·83	7·01	6·81	6·90
XVI.	5·88	6·43	6·04	6·25	6·22	6·18	6·21	6·09	6·19	6·38	6·24	6·26	6·24	6·19	6·21	6·23	6·19	6·24	6·26
Crab C.	6·82	6·51	6·69	6·78	6·82	6·42	6·66	6·58	6·66	6·76	6·73	6·62	6·67	6·58	6·67	6·68	6·67	6·61	6·67
Sig. diff.	1·17	0·89	1·07	1·03	0·95	1·00	0·91	1·13	0·90	1·08	0·81	0·92	0·84	0·93	0·95	0·93	0·96	0·90	0·88
"V."	14·5	10·8	13·2	12·6	11·8	12·4	11·3	14·1	11·2	11·5	10·0	11·3	10·3	11·7	11·7	11·4	11·8	11·2	10·8
Size.																			
XII.	3·16	3·24	3·17	3·15	3·14	3·24	3·23	3·22	3·18	3·24	3·21	3·25	3·21	3·19	3·20	3·21	3·23	3·19	3·21
XVI.	2·90	3·06	2·97	2·95	2·97	2·99	2·98	2·93	3·00	3·02	2·95	2·97	2·97	2·97	2·96	2·98	2·96	2·99	2·97
Crab C.	3·09	3·11	3·20	3·15	3·18	3·06	3·10	3·08	3·11	3·14	3·16	3·11	3·14	3·12	3·13	3·15	3·16	3·11	3·14
Sig. diff.	0·39	0·35	0·33	0·29	0·34	0·32	0·31	0·31	0·31	0·29	0·31	0·29	0·33	0·33	0·31	0·29	0·32	0·31	0·31
"V."	10·4	9·1	8·7	7·6	8·9	8·4	8·1	8·2	8·2	7·6	8·2	7·5	8·5	8·4	8·2	7·5	8·3	8·1	8·0

coefficient of variability (V) obtained for colour and size respectively with increasing numbers of apples to a sample. It is evident that in size of fruit the trees are considerably more even than in colour, and that in size there is no added advantage in increasing the sample number beyond eighty apples or about one-eighth of the total crop. At this point the coefficient of variability is about 8 per cent. and remains thus for all larger samples. The variation between like trees in colour is considerably higher; but the advantage in increasing the samples above 120 apples is not great. The coefficients are about 12 per cent. for samples of 120 apples and this only decreases to 10·8 per cent. for the whole crop.

It will be noticed that the variation both in size and colour is considerably higher than that recorded in 1934 for Bramley's Seedling. One possible reason for the higher colour variation is that the difference between a shaded apple and one receiving full sunlight, would tend to be greater with Allington as compared with the naturally green Bramley's Seedling. The apples on a single tree would be more variable, and this might extend to differences between whole trees. The fact that the trees were rather more widely distributed in the plantation and included a few headland trees may account to some extent also for the higher variation in both size and colour.

The period of grading was also considerably longer, but there does not seem to have been the same colour increase during the time on this occasion.

Although it is possible that smaller samples might have sufficed for Bramley's Seedling, taking the two studies together, it seems, that for mature trees bearing a full crop, samples of about one-eighth of the crop are ample to show size differences of importance. A sample of this size will give fair accuracy for colour, but should be increased if the important colour differences are of a low order or if the number of replicates is small.

In the present instance with six replicates, samples of eighty apples were sufficient to prove significant differences of about 16 per cent. in average colour and 10 per cent. in average size.

Acknowledgment.

Grateful thanks are due to Mr. A. V. Voss for help with the recording and colour grading of this experiment.

Summary.

An experiment in sampling the crops of fourteen-year-old Allington Pippin trees, with a full crop, for size and colour of fruit, is described. It is concluded that with normal replication of such trees it is only necessary to grade about one-eighth of the crop of each tree, selected at random from the whole, to obtain reasonably accurate estimates of the average size and colour "figures", usually computed for comparison of these characters.

References.

(1) Edgar, J. L. and de Wet, A. F. "An Experiment in Sampling Technique for Size and Colour of Apples—Bramley's Seedling on Rootstock No. II—1934 Crop." E. Malling Res. Sta. Ann. Rep. for 1934 (1935), 130-5.

(2) Hoblyn, T. N. "Field Experiments in Horticulture." Imp. Bur. of Fruit Prod. T.C. 2, 1913.

(3) Hoblyn, T. N. and Bane, W. A. "Apple Manurial Trials." E. Malling Res. Sta. Ann. Rep. for 1933 (1934), 59-85.

PHYSIOLOGY

PRELIMINARY OBSERVATIONS ON THE CARBOHYDRATE CONTENT OF APPLE LEAVES ON DIFFERENT ROOTSTOCKS*

By E. R. LEONARD

I. Introduction.

The influence of the rootstock on the growth of apple trees is manifest in differences in vigour, precocity and disease resistance. Vigour is estimated as increase in stem length, total weight, height and spread, stem girth or total leaf area, i.e. different measurable attributes of the total growth processes. The greater part of the synthesis of plant material takes place in the leaves and the amount produced depends on " the area of the leaf surface exposed to light, the proportion of this surface which intercepts only diffuse light and upon the relative intrinsic efficiency of the leaves as photosynthetic organs. It is conceivable that a rootstock may influence the photosynthetic activities of a scion by affecting any of these conditions " (2).

Preliminary investigations at the East Malling Research Station have shown that the Sachs-Thoday half-leaf method is difficult to apply in the case of the apple leaf owing to the large proportion of inactive material relative to the products of photosynthesis, and to the great variability between individual portions of leaves from different trees on the same stock. Starch estimations by a colorimetric method were also unsatisfactory. It was therefore decided to undertake the more lengthy process of estimation of carbohydrates by chemical analysis. It is realized that in the present state of knowledge of the carbohydrates involved in assimilation, and of the methods of analysis available, little reliance can be placed on the results of analyses as indicating the exact quantities of any specific compound present, but it is hoped that, by the use of the same routine of analysis of the leaves from trees differing solely in respect of rootstock, comparable estimates of the photosynthates can be obtained, and their daily cycle compared.

II. Preliminary Investigations.

1. *Methods of Analysis.*

The Hagedorn-Jensen and the hypoiodite methods as modified by Widdowson (4) for the estimation of small quantities of reducing sugars and starch were tested without special purification of the A.R. sugars or starch and an accuracy to within 1 per cent. of the quantity of carbohydrate present was obtained.

Tests were also made, using pure sugars, to determine the possibility of utilizing yeast fermentation as a means of discriminating between the reducing power due to sugars and other substances in extracts of leaves. It was found that 1 c.c. of 1 per cent. yeast suspension fermented more than 90 per cent. of the sugar contained in 5 c.c. of

* Thesis approved for the Degree of Master of Science in the University of London. This work was carried out at East Malling while the author was attached to the Research Institute in Plant Physiology at the Imperial College of Science and Technology, London.

0·06 per cent. solutions of dextrose, laevulose and maltose in 24 hours as determined by the ferricyanide method, while increasing the time or quantity of yeast produced only slight decrease in the amount of residual sugar. Yeast fermentation did not appear suitable for use with the hypoiodite method.

A blank estimation was also made by boiling alcohol alone under a condenser and carrying it through the clearing processes detailed below, and other blank estimations were carried out on samples of the various spray solutions as applied to the trees. In no case was any appreciable reducing substance found.

2. *Preparation of Material.*

Considerable attention was devoted to the methods of collection, preservation and analysis of the leaf material.

In October and early November samples of leaves were taken from 150 maiden trees of the variety Lane's Prince Albert budded on fifty No. XII stocks (very vigorous type) and one hundred No. IX (very dwarfing type). These stocks produce extremes of vigour and precocity in scion varieties worked on them. The fresh weight and area were obtained of each sample, which was then either killed and preserved in alcohol or dried in electric ovens. The alcohol-preserved leaves were killed with, and without, the addition of alkali to neutralize the acids present; the dried leaves were killed in ovens at different temperatures to determine the optimum rate of killing and of desiccation to minimize hydrolysis. Comparable samples were taken of the two methods.

Analyses of the dried leaf material were first undertaken. Weighed portions of ground material were extracted with boiling alcohol under an air-tube condenser. The alcohol was boiled off under reduced pressure and the extract taken up in water. The aqueous solution thus obtained was cleared with sufficient basic lead acetate (prepared as described in Allen's "Commercial Organic Analysis", Vol. I) to precipitate the proteins, etc., present (2 c.c. per 1 gm. fresh weight of leaf was found necessary), deleaded with saturated sodium phosphate, and the precipitate filtered off under reduced pressure. The solutions thus obtained were yellow and were made up to a suitable volume. When the reducing substances present were estimated by the two methods the results, calculated as dextrose, were quite incompatible. Further extracts were prepared of a strength sufficient to enable estimations to be made by Lane and Eynon's modification of Fehling's method; by this method the dextrose percentage was in close agreement with that found by ferricyanide. Decolorization of the solutions by boiling with Suchar charcoal reduced the differences between the two methods, and also reduced the dextrose percentage as determined by ferricyanide.

No invert sugar or starch was found in these samples of leaves collected in October and November. On analysis of fresh leaf material available on the trees (May) the reducing substances were found to be present in considerably smaller quantity and it was not until the size of the sample had been increased to fourteen leaves that the lower limit of reliability of the ferricyanide method was reached.

When starch estimations were attempted on the sugar-free residue similar difficulties were encountered, as regards the evaluation of dextrose and maltose after hydrolysis, as had been found in the case of the reducing sugars. The removal of interfering substances by shaking the aqueous solutions with ether or chloroform was tried but was found ineffective though it brought about a reduction in the discrepancy between the methods. A large bulk of dried leaf material was therefore ground to a powder and extracted with successive quantities of ether in a Soxhlet apparatus till no further loss in weight occurred. The residue was then extracted with 90 per cent. alcohol, the

alcohol evaporated off under reduced pressure and the extract taken up in water. Aliquots of this aqueous solution were then cleared using

(1) basic lead acetate
(2) neutral lead acetate } and deleading with sodium phosphate.
(3) dialysed iron and precipitating excess with saturated sodium sulphate.

In each case the final cleared solution was slightly yellow and was decolorized by boiling with small quantities of Suchar charcoal and filtering.

On analysis by the two methods the reducing substances (calculated as dextrose) were less in the case of the hypoiodite than the ferricyanide method which is a necessary condition if reliance is to be placed on the combination of the two methods for the fractionation of the reducing sugars. Agreement between the two methods was not very close, the results as mgm. dextrose in 5 c.c. solution being :

Clearing Reagent.	Method of Analysis.	
	Ferricyanide.	Hypoiodite.
Basic Lead Acetate	2·121	1·891
Neutral Lead Acetate	2·393	2·000
Dialysed Iron	2·354	2·225

No increase in reducing power of the solutions was obtained by acid hydrolysis.

The precipitates obtained by means of the three clearing agents were examined for the presence of glucosides by boiling with 2 per cent. hydrochloric acid under a reflux condenser for two hours, cooling, neutralizing and clearing with the same reagent as previously ; no appreciable amounts of reducing substances were found after this treatment, indicating the absence of any considerable quantity of glucosides.

A further sample of dried material was ground, extracted with ether, dried, extracted with alcohol and taken up in water as before. The extract thus obtained was divided into two portions one of which was neutralized to phenolphthalein with caustic soda solution—a somewhat unsatisfactory process owing to the high colour of the solution—and aliquots of the neutralized and slightly acid solutions were then cleared with the same three reagents as before. Portions of these cleared solutions were analysed in the coloured condition and after decolorizing with Suchar charcoal, with the following results :

	Clearing Reagent.	Colour after clearing.	"Dextrose" in 5 c.c. Sol.	
			Ferricyanide.	Hypoiodite.
Acid Solution	Basic Lead Acetate ..	Very pale yellow ..	1·929	1·752
		Decolorized	1·738	1·442
	Neutral Lead Acetate ..	Strong yellow	2·140*	2·540*
		Decolorized	1·839	1·441
	Dialysed Iron	Pale yellow	2·079*	2·216*
		Decolorized	1·689	1·324
Neutralized	Basic Lead Acetate ..	Nearly colourless ..	2·025	1·822
		Decolorized	1·826	1·549
	Neutral Lead Acetate ..	Strong yellow	2·233	2·216
		Decolorized	1·925	1·541
	Dialysed Iron	Very pale yellow ..	2·117	2·009
		Decolorized	1·887	1·531

It is evident that the completeness of clearing is dependent on the clearing reagent used and since basic lead acetate gave the least coloured solution and the lowest quantity of " dextrose " it was decided to use this reagent throughout.

It is also seen that in some cases (marked with an asterisk) the previous discrepancy between the two methods of analysis still occurred.

Further ether extractions were made on dried material, the ether-soluble portion taken up in water (so far as this was possible) and the ether evaporated off. The aqueous solution was then cleared with basic lead acetate, deleaded and analysed for ferricyanide-reducing substances. These were found to be present in considerable quantity but their nature is unknown. Subsequent alcohol extraction yielded further quantities of reducing substances, from which it appears that alcohol extraction without previous ether extraction is likely to give yields of reducing substances in excess of the true value for reducing sugars only.

The above analyses were all performed on material known from previous examination to be free from starch. Analysis of starch-containing leaves was now undertaken, the method used being, ether extraction, followed by alcohol extraction and Taka-diastase hydrolysis of the residual material ground to a paste and boiled with water. It was found impossible to apply the method as given by Widdowson, and it was therefore decided to abandon the hypoiodite method and rely on the ferricyanide estimations for direct- and acid-hydrolysable reducing substances and to make use of acid hydrolysis following Taka-diastase digestion for starch.

As samples of the size found necessary represented 20 per cent. of the total leaf number and leaf area of the maiden trees it was evidently necessary to work with older trees. These were available on the older-established plots.

III. Carbohydrate Content during the Daily Cycle.

1. *Collection and Preparation of Samples.*

Samples of leaves for analysis were taken from three adjacent sixteen-year-old trees of Lane's Prince Albert on each of the two stocks. Each individual sample consisted of about twenty leaves which were selected on the day previous to the sampling. They included all the leaves from three or four adjacent non-fruiting spurs (growths of less than 5 cm. length) on one-year-old wood (total area about 300 cm., total fresh weight 5-10 gm.). Owing to the contrasted morphological development produced in any variety of apple worked on these two stocks this was the only type of growth available in sufficient quantity on both. The spurs selected were labelled and the areas of the leaves obtained by means of the " integrator " as used by Vyvyan and Evans (3). As far as possible spurs were selected in positions towards the outside of the tree and receiving equal illumination.

On five occasions—at 6 a.m., noon, 6 p.m., midnight and 6 a.m. the following day (31st August to 1st September)—collections of samples were made. One sample was taken from each tree on each occasion giving a total of six samples on each occasion and a grand total of thirty separate samples (three replicate trees × two stocks × five occasions). The leaves were cut off at the junction of the lamina and petiole, placed in small aluminium boxes with tight-fitting lids and taken to the laboratory. Any surface moisture was rapidly blotted off and the fresh weight of the leaves obtained to the nearest 0·01 gm. The boxes and leaves were then placed in a flat metal tray constructed to fit the bottom of an electric oven. A metal lid was placed over the tray with a sponge-rubber gasket. The tray was heated in the oven to 50° C. whilst a vacuum of 1·5 to 1 cm. of mercury was produced inside by means of a Geryk pump. This

initial drying occupied one hour and was followed by drying *in vacuo* at 50° C. for a further four hours. It was found that not less than 70 per cent. of the total loss in weight took place during the first hour of drying, and the dried leaves showed practically no browning of the tissue.

2. *Methods of Analysis.*

Each sample of dried leaf material was ground to a fine powder with a pestle and mortar, transferred to a Soxhlet extraction thimble and extracted with 100 c.c. of 90 per cent. alcohol for forty-eight hours. The alcohol extract was evaporated off under reduced pressure at 30° C. and taken up in water. The dark green solution was then cleared with basic lead acetate and the dense precipitate filtered off under reduced pressure. The excess lead acetate was removed by precipitation with saturated disodium phosphate, and the cleared solution, which was very pale yellow, was made up to 100 c.c. Aliquots were taken for the estimation of (*a*) direct reducing substances, (*b*) direct reducing substances after decolorization by boiling with Suchar charcoal, (*c*) reducing substances after hydrolysis, (*d*) reducing substances after hydrolysis and subsequent decolorization. Hydrolysis was carried out by heating with concentrated hydrochloric acid at 70° C. for fifteen minutes followed by neutralization to phenolphthalein with 10N caustic soda ; the final end point was obtained by the addition of 5 per cent. acetic acid.

Estimation of the sugars in these solutions was made by means of the semi-micro alkaline ferricyanide method, with slight modifications; 5 c.c. of solution were pipetted into each of four 1 inch diameter × 4 inch specimen tubes and 5 c.c. of solution A added. Two of the tubes were placed in a boiling water bath for twenty minutes whilst the other two were kept in running tap water. The two heated tubes were then cooled for five minutes in tap water. 5 c.c. of solution B and 2 c.c. of solution C were added to each tube and the liberated iodine titrated with N/75 sodium thiosulphate. The difference between the mean values of the burette readings for the cold and heated tubes gives the volume of thiosulphate equivalent to the iodine liberated, and the weight of sugar present in 5 c.c. of solution was obtained by reference to a table constructed from Widdowson's published figures.

Starch was estimated in the alcohol-insoluble residue by digestion with Taka-diastase and subsequent acid hydrolysis. The residue after alcohol extraction was dried *in vacuo*, ground with a small quantity of distilled water and boiled in a conical flask for thirty minutes. After cooling, 1 c.c. of 0·25 per cent. Taka-diastase suspension, two drops of 5 per cent. acetic acid and a small quantity of toluene were added. A blank consisting of distilled water and Taka-diastase was also prepared and the two flasks, plugged with cotton wool, were incubated at 37° C. for twenty-four hours. The solutions were then boiled, filtered and cleared with basic lead acetate and disodium phosphate. They were then boiled with 2 c.c. of concentrated hydrochloric acid for four hours, cooled, neutralized as in the case of the alcohol-soluble fraction and made up to 100 c.c. The dextrose produced by hydrolysis of starch was estimated by the alkaline ferricyanide method, the distilled water and diastase serving as blank titration. Starch was calculated from the dextrose by means of the factor 0·9. No starch was observed in the final residue after diastase digestion.

Experimental Results.

The results of the analyses which have been completed are given in Tables I-V, in which reducing substances calculated as dextrose, and starch are given as percentages of the dry and fresh weights of the leaves. The acid-hydrolysable fractions represent

the increase in reducing power of the solutions after acid hydrolysis, i.e. the difference between the aliquots (*a*) and (*c*), (*b*) and (*d*), and are calculated as sucrose.

No calculations have been made on the basis of leaf area but there was no marked difference in the ratios fresh weight/area or dry weight/area between the two stocks. A reduction in weight amounting to about 3 per cent. of the fresh weight at the 6 a.m. collection occurred between that and the noon collection but no consistent difference was found in this respect between the two stocks, i.e. the transpiration rate on the two stocks is not markedly different. This is in agreement with Knight's (1) observation that although the stock themselves exhibit differences in transpiration rates, individuals of one variety worked upon the different stocks do not show any differences.

TABLE I.

REDUCING SUBSTANCES AS DEXTROSE.

	% D.W.				% F.W.			
Collection.	Stock IX.	Mean.	Stock XII.	Mean.	Stock IX.	Mean.	Stock XII.	Mean.
6 a.m. ..	1·94 2·37	2·16	1·34 1·82	1·58	0·75 0·88	0·82	0·53 0·72	0·63
noon ..	3·94 2·22	3·08	1·56 2·77	2·17	1·65 0·96	1·31	0·67 1·13	0·90
6 p.m. ..	2·42 2·81	2·62	2·29 2·40	2·35	1·05 1·16	1·11	0·99 1·03	1·01
midnight ..	2·75 3·16	2·96	2·10 1·88	1·99	1·17 1·28	1·23	0·94 0·79	0·87
6 a.m. ..	2·37		2·10		0·94		0·83	

TABLE II.

NON-CARBON ABSORBED, REDUCING SUBSTANCES AS DEXTROSE.

	% D.W.				% F.W.			
Collection.	Stock IX.	Mean.	Stock XII.	Mean.	Stock IX.	Mean.	Stock XII.	Mean.
6 a.m. ..	1·21 1·80	1·52	0·71 1·07	0·89	0·47 0·67	0·57	0·28 0·42	0·35
noon ..	2·21 1·72	1·97	0·92 1·24	1·08	0·93 0·74	0·84	0·39 0·50	0·45
6 p.m. ..	1·86 2·15	2·01	1·02 1·48	1·25	0·81 0·87	0·84	0·44 0·64	0·54
midnight ..	2·33 1·71	2·02	1·35 0·77	1·06	0·99 0·69	0·84	0·60 0·32	0·46
6 a.m. ..	1·68		0·95		0·67		0·37	

Table III.

Acid-Hydrolysable Reducing Substances as Sucrose.

Collection.	% D.W. Stock IX.	% D.W. Mean.	% D.W. Stock XII.	% D.W. Mean.	% F.W. Stock IX.	% F.W. Mean.	% F.W. Stock XII.	% F.W. Mean.
6 a.m. ..	0·53	0·59	0·23	0·36	0·20	0·22	0·09	0·14
	0·65		0·48		0·24		0·19	
noon ..	1·57	1·40	0·70	0·88	0·66	0·60	0·30	0·37
	1·23		1·06		0·53		0·43	
6 p.m. ..	1·37	1·34	0·87	0·91	0·60	0·57	0·38	0·40
	1·31		0·95		0·54		0·41	
midnight ..	0·84	1·13	0·77	0·79	0·36	0·47	0·34	0·34
	1·42		0·80		0·57		0·34	
6 a.m. ..	0·93		0·80		0·37		0·31	

Table IV.

Non-Carbon absorbed, Acid-Hydrolysable Substances as Sucrose.

Collection.	% D.W. Stock IX.	% D.W. Mean.	% D.W. Stock XII.	% D.W. Mean.	% F.W. Stock IX.	% F.W. Mean.	% F.W. Stock XII.	% F.W. Mean.
6 a.m. ..	0·36	0·18	0·23	0·34	0·14		0·09	0·14
	0·01		0·45		—		0·18	
noon ..	1·12	0·74	0·66	1·00	0·47	0·32	0·28	0·41
	0·36		1·34		0·16		0·54	
6 p.m. ..	0·65	0·67	0·36	0·30	0·28	0·29	0·16	0·13
	0·69		0·24		0·29		0·10	
midnight ..	0·25	0·33	0·84	0·67	0·11	0·14	0·37	0·29
	0·40		0·50		0·16		0·21	
6 a.m. ..	0·39		0·88		0·16		0·35	

Table V.

Starch.

Collection.	% D.W. Stock IX.	% D.W. Mean.	% D.W. Stock XII.	% D.W. Mean.	% F.W. Stock IX.	% F.W. Mean.	% F.W. Stock XII.	% F.W. Mean.
6 a.m. ..	0·21	0·23	0·15	0·21	0·08	0·09	0·06	0·08
	0·24		0·27		0·09		0·10	
noon ..	0·27	0·28	0·27	0·31	0·11	0·12	0·11	0·13
	0·29		0·35		0·12		0·14	
6 p.m. ..	0·37		0·27		0·15		0·12	
midnight ..	0·33		0·25		0·14		0·11	
6 a.m. ..	0·39		0·38		0·15		0·15	

Conclusions.

It has unfortunately proved impossible to complete the analysis of the three replicates, but it will be observed that a consistent difference is demonstrable between the " dextrose " and " sucrose " content of leaves on the two stocks throughout the period of sampling. Those on No. IX have, in all except three instances in Table IV, values higher than those on No. XII.

Starch was present in small quantity only.

Similar results as regards the content of " dextrose " and " sucrose " were obtained in the preliminary analyses carried out during the previous year using leaves taken from maiden trees of the same variety on the same two stocks. The starch content was again low.

Summary.

Preliminary estimations of the alcohol-soluble, reducing substances present in leaves of a variety of apples grafted on two stocks showing extremes of vigour indicate that quantitative differences exist, the dwarfing, precocious stock having leaves of consistently higher content throughout a twenty-four-hour cycle.

Acknowledgments.

The writer wishes to acknowledge his thanks to Professor V. H. Blackman under whose supervision this work was carried out and to the Director and members of staff of the East Malling Research Station for facilities provided.

Literature Cited.

(1) Knight, R. C. E. Malling Res. Sta. Ann. Rep. for the year 1924 (November, 1925), 103.

(2) ——— E. Malling Res. Sta. Ann. Rep. for the year 1928 (April, 1929), 87.

(3) Vyvyan, M. C. and Evans, H. " The Leaf Relations of Fruit Trees. I. A Morphological Analysis of the Distribution of Leaf Surface on Two Nine-year-old Apple Trees (Laxton Superb)." Journ. Pom. and Hort. Sci., 1932, **10,** 228-270.

(4) Widdowson, E. M. " A Method for the Determination of Small Quantities of Mixed Reducing Sugars and its Application to the Estimation of the Products of Hydrolysis of Starch by Taka-diastase." Biochem. J., 1931, **25,** 863-879.

MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1937

By H. WORMALD and R. V. HARRIS

NON-PARASITIC DISEASES.

Of the common functional diseases of fruit Bitter Pit in apples was again prevalent. Another disease, which appears to be related to ordinary Bitter Pit and has been called " Blotchy Pit ",* was seen on Newton Wonder apples received from Buckinghamshire.† The symptoms are irregular sunken areas, dark green blotched with brown, and more conspicuous than ordinary Bitter Pit ; in the specimens examined these markings were confined to the eye-end of the fruit.

A disease which is thought to be a form of Bitter Pit sometimes occurs on pears. The pitting, however, is deeper than in apples, and pears with this disease are often deeply dimpled and very irregular in shape (Dimpled Pears). Specimens showing this disease were received from near Canterbury, the variety chiefly affected being Louise Bonne, but there was a little on Dr. Jules and on Conference.

In the last report mention was made of a disease affecting cherry trees, the symptoms being leaf-spots and shot-holes. These general symptoms are rather like those brought about by infection of the leaves with the Bacterial Canker organism, but no bacteria could be found in the spots. The disorder was prevalent again in 1937, not only on cherries but on certain varieties of plum also, particularly River's Early, Czar, and Monarch. At present the cause of this trouble is unknown. Observations in 1937 indicated that in plums the rootstock might affect the degree to which symptoms show. Thus trees on Brussels stocks showed this disorder more than those on Myrobolan.

Non-Parasitic Disease of Raspberry.

The development of fruit-laterals in the plantations of Lloyd George at the Research Station during the early spring period was extremely irregular, many of the fruit canes exhibiting at this time severe symptoms of " Dwarf-lateral Scorch ". Later, however, these symptoms became less pronounced on many canes, and a heavy crop was eventually obtained.

Similar cases were observed elsewhere, but on certain plantations on the heavier soils of the Kentish Weald the early sub-normal development of laterals persisted, and the crop was adversely affected.

Experiments during the year (see p. 93) have shown that a relatively high mean-temperature during the dormant period is a primary cause of this disease and the prevalence of symptoms in 1937 is therefore clearly correlated with the mild character of the preceding winter. That other causal factors are also concerned, however, is clear from the high degree of natural recovery in the instance mentioned above.

DISEASES CAUSED BY FUNGI.

Brown Rot Diseases. Blossom Wilt of cherries, caused by *Sclerotinia laxa*, was again severe in parts of Kent. One grower wrote from Charing Heath, " I have—

* This disease was identified by Mr. H. Hill.

† We are indebted to Professor Wm. Brown who sent us these specimens.

together with other growers in this district—a lot of Blossom Wilt in the sweet cherries, especially the black varieties ; in the case of Circassians it amounts to the whole of the trees being affected. The trees are affected mostly round the bottoms, and what few cherries there are on the tops of the trees."

On Morello cherries also Blossom Wilt caused much damage. At East Malling but few infections occurred through the unopened flowers, but later infections, through the open flowers, were numerous, even on sprayed trees, and the severity of infection was believed to be due to infection coming from a row of damsons and Czar plums which were to the west of the Morellos, for Blossom Wilt was far the worst on the west side of the cherry plot.

During May Morello shoots were found which had become infected through the leaves. On each of these shoots infection had started on a leaf from which the fungus had invaded the shoot itself, causing it to wilt. Such wilting of the young shoots (Wither Tip), though common in plums, is unusual in cherries and we have not previously seen it in Morello cherries.

Later in the season (early August) some of the Morello fruits became infected with the common fruit rot fungus *Sclerotinia fructigena*. In each specimen examined it was seen that the fungus had grown along, within the stalk, into the twig to produce a lesion, from which a drop of gum was exuding.

Wither Tip (*Sclerotinia laxa*) was severe on Victoria plum shoots received from Suffolk. It has been generally assumed that in this disease infection begins on the leaves, from which the fungus extends into the shoots to cause the wilting. In some of these Suffolk specimens, however, it appeared that infection did not always start on the leaves and then enter into the shoot, for lesions were seen when the leaves were not affected, some of the lesions being at the nodes but on the side opposite to the leaf.

From time to time the Brown Rot fungi are found on ornamental shrubs, and in 1937 specimens showing a twig blight of *Pyrus floribunda purpurea* were sent to us from Hampshire. The specimens when received were rather old and overrun by saprophytic fungi. Their condition, however, suggested infection by *S. laxa*, and it was possible to isolate, from the internal tissues of the twig, a fungus which proved to be *S. laxa*, the cause of Blossom Wilt in various species of Pyrus and Prunus. In the Report for 1935 both *S. laxa* and *S. fructigena* were mentioned as found on *Pyrus floribunda*. The possibility of cross infection from such plants to fruit trees and vice versa must not be overlooked, especially in nurseries and private gardens where ornamental shrubs and fruit trees may be growing in close proximity.

Observations were again made on the rotting of plums in cold storage. As in former years (see Report for 1934, p. 148, and for 1936, p. 198) most of the wastage was due to Brown Rot infection, chiefly by *Sclerotinia fructigena*, though *S. laxa* was present also.

Hawthorn Leaf Blotch. This disease was unusually prevalent in 1937. It had previously been noted in the neighbourhood of Maidstone and East Malling, the first record of its occurrence in this country appearing in the Report of this Station for 1926-7 (p. 86). Since 1926 it had appeared sporadically, and caused but little damage, until 1937, when it was found in several localities, being particularly severe round Cambridge. The disease has been referred to as Brown Rot but it is preferable to call it Leaf Blotch as this is more descriptive of the symptoms and also serves to distinguish this disease from those caused by the true Brown Rot fungi. So far as is known the fungus which causes this leaf blotch, *Sclerotinia Cydoniae*, is confined to the hawthorn and does not infec fruit trees, although the quince and the medlar have each a leaf blotch fungus.

Sooty Blotch. Although this disease was so severe in 1936, as described in the last Report, during 1937 it was hardly noticeable. It was not seen at all on apples at this Station, but it occurred again on Warwickshire Drooper plums, a variety which appears to be particularly susceptible, as mentioned in previous Reports. Even on this variety, however, it was far less severe than in former years. Only a few were infected and the blotching was not conspicuous on any of them, so that treatment was unnecessary.

Blotched apples which had received the chloride of lime treatment,* together with others untreated, as controls, were kept in ordinary cool storage over winter. When examined in March, 1937, the treated apples were still clean indicating that the Sooty Blotch fungus, *Gloeodes pomigena*, must have been killed, while on the untreated apples the fungus had developed further and the blotches were far more conspicuous than when the fruit was put into storage.

Eye-rot in Apples. This disease is one to which Worcester Pearmain is particularly susceptible. The fruit is attacked at the eye, killing the tissues there, so that the eye-end becomes discoloured and flattened, and bears the Fusarium pustules of the fungus, which is considered to be *Nectria galligena*, the cause also of Apple Canker. In 1937 it appears to have been very common. Specimens were received from Sussex and Surrey, and visitors to the Station said it was prevalent.

Quince Leaf Blight. In the report for 1936 reference was made to the relative susceptibility of Quince A and Quince C, both commonly used as rootstocks for pears. This leaf blight, caused by the fungus *Fabraea maculata* (*Entomosporium maculatum*), as observed on stocks at this Station, is consistently more severe on Quince C than on Quince A. In June quince leaves showing the spotting were received from a nursery in Hertfordshire. Although it was so early in the season the stocks of Quince C were already very severely infected ; those of Quince A also showed infection, but on this variety the disease was less severe. This offers confirmation of the conclusion arrived at from observation at East Malling, that Quince C is more susceptible than Quince A to this disease.

Verticillium Wilt of Quince Stocks. Further infection of Malling Quince C stocks was noted in June on " budded " and " non-budded " two-year-old trees.†

At this time the leaf development on the unbudded trees was seen to be defective, and on cutting the main stems of the trees in both series a greenish-black coloration of sectors of the wood was invariably found. Transverse sections of the discoloured tissues readily and constantly yielded pure cultures of *Verticillium Dahliae* Kleb. Attempted isolations from the base of the " bud shoots " of the scion variety, on the other hand, were invariably unsuccessful, indicating that the organism was at this time confined to the wood elements of the stock.

Wilting of Shoots in Layer Rows of Prunus spp. In the main plum rootstocks in Newgates Field this disease caused far less damage than in 1936 ; this was probably a result of the drier weather which prevailed round about the time that the layer rows were being earthed up. In the experimental plots, however, it was again severe, many shoots being killed. As mentioned in the last Report the fungus associated with this disease is a species of Cylindrocladium, closely related to *C. scoparium*, which causes a disease in roses. It has been compared in culture with *C. scoparium* from roses and also with strains isolated from raspberry and strawberry in Canada and so far as the tests have gone it is indistinguishable from the raspberry and strawberry strains.

* See Annual Report for 1936, p. 194.

† We are indebted to Dr. W. T. Chang for drawing our attention to these diseased trees.

Cherry Leaf Curl. This disease is caused by a fungus *Taphrina minor* which is closely related to that which produces Witches' Brooms or "bull-wood" in cherries, and also to the Peach Leaf Curl fungus. In Cherry Leaf Curl the leaves become wrinkled but the branches do not produce the numerous shoots typical of Witches' Brooms. Early in June it was seen on a Morello cherry branch received from Sussex; many of the leaves were blistered and distorted.

Grey Mould on the Morello Cherry. Another cause of wilting in shoots of Morello cherries, in addition to the Brown Rot infection mentioned above, is Grey Mould. During May wilted shoots brought in from plots on this Station showed no obvious fungus, but when kept in a moist chamber for a few days *Botrytis cinerea* appeared on them. This fungus is known to attack many host plants, but it is only troublesome in wet weather or when plants are grown under very moist conditions. This attack on the Morello is probably exceptional, and a result of the wet spring.

Collar Rot of Red Currant. This disease usually attacks currant bushes which are past their prime, and in the last Report (p. 190) its occurrence on some of the older bushes on the Station was mentioned. In 1937 the disease was again found, this time on a few of the younger bushes (about 10 years old), one of them bearing fructifications of *Fomes Ribis* which formed a cluster 6 inches across, encircling the collar, just above ground level.

Coral Spot. The Coral Spot fungus *Nectria cinnabarina* is of fairly common occurrence on the red currant and it was found on this host on this Station. Specimens from walnut and from apple trees bearing the same fungus were received during 1937. On walnut the fungus was borne on the young twigs; these were of unripened wood and it is probable that the dying back was primarily due to winter injury, the fungus living saprophytically on the dead parts.

An apple specimen received from Essex showed a long canker bearing numerous pustules of the conidial stage of the fungus. The infected portion extended for 18 inches along the stem of a three-year-old James Grieve tree. The stem was killed to the base of the scion but healthy shoots were growing from the upper end of the stock. The occurrence of Coral Spot on apple trees was mentioned in the Report for 1936, and had been observed previously. The Coral Spot fungus is not nearly so widespread on apple trees as the common canker fungus, *Nectria galligena*, but its frequent appearance on currant bushes make these a possible source of infection for apple trees.

Black Currant Leaf Spot, caused by *Pseudopeziza Ribis* (*Gloeosporium Ribis*), was on the whole less severe in 1937 than in 1936, but several enquiries about it were received and in some plantations much damage was caused, the bushes being partly defoliated during July. An Essex grower, towards the end of July, said that some of his bushes had lost all their leaves. The specimens accompanying the letter were from the variety Wellington's XXX. Other varieties with severe infection during July were Daniel's September Black, and Baldwin.

American Gooseberry Mildew has not been so prevalent in recent years as formerly as a result of the efforts of growers to keep it in check. About the middle of June, however, specimens (of the variety Lancashire Lad) were received showing severe infection; the smaller berries were completely invested with the fungus and, on some of the fruits, perithecia (of the so-called winter stage) were already present.

Fungus Diseases of Raspberry and Loganberry. An exceptionally severe direct infection of fruit-laterals and berries with Cane-spot (*Elsinoë veneta*) occurred in raspberry

and loganberry plantations at the Research Station, and similar cases were observed in other and widespread localities. Conditions in 1937 were also generally favourable for a severe Cane-spot cankering of the current season's raspberry canes and loganberry bines, and it was particularly pronounced where the latter had been temporarily trained immediately underneath the fruit bines.

Spur-blight (*Didymella applanta*) was also very prevalent in the Research Station plantations and the "Leaf Blotch" phase was exceptionally severe on a certain seedling variety.

Verticillium Wilt of Strawberries. In July, Mr. W. G. Kent called our attention to a disease of the Huxley's Giant variety near Canterbury. The outer and older leaves of large well-grown plants had begun to wilt and were dying prematurely shortly before cropping, with the result that most of the crop from these plants was under-sized and malformed.

A blue-black streak was present on the petioles of wilting leaves and also on the fruit stalks and pedicels, extending upwards from the point of attachment to the crown. The cortical tissues in the region of this streak were irregularly collapsed giving the petiole or stalk a "stringy" and twisted appearance. A microscopical examination of transverse sections made near the bases of these organs showed that the wood elements of the vascular strand in the discoloured region were invaded by fungal hyphae, and on transferring further sections to agar plates pure cultures of *Verticillium Dahliae* Kleb. were readily obtained.

It is proposed as time permits to make inoculations in confirmation of the parasitism of the above organism.

During the same month two further cases of this disease were reported from the same district, this time on the Royal Sovereign variety.

Grey Mould on Strawberries. The chief fungal disease of strawberries during the year was a rot of the fruit brought about by the common Grey Mould, *Botrytis cinerea*. The rot was very destructive on this Station, and many complaints of the losses incurred from this disease were received from various localities. The outbreak followed a period of wet weather, and it is generally recognized that Grey Mould is most troublesome under conditions of excessive moisture. On certain plots an attempt to check the progress of the rot was made by slipping rubber bands over the plants so as to raise the fruit above the ground and expose it more to air and light. Some success was obtained but it is doubtful whether such a practice would be profitable under commercial conditions. On the plot where the disease was particularly severe the rows ran east and west, and it was found that the disease was worse on the north side of the rows than on the south side.

The Silver Leaf Fungus on Walnut. A walnut tree on this Station had been cut back early in January to induce the growth of shoots which would be suitable for graft-wood. By November some of the branches which had been cut had died back for a distance of 3 to 9 inches, and fructifications of *Stereum purpureum* were present on the dead portions. The cut ends had been covered with grafting wax, but apparently this was not sufficient protection to prevent infection.

Verticillium Wilt of Hops. Three further outbreaks of this disease were identified in Kent during 1937. In this season the attack was very severe in most of the infected gardens, and was correlated with the exceptionally heavy rainfall during the preceding winter, with the consequent slow disposal of spring water during the growing season.

The original case of this disease to be recorded (i.e. at Penshurst in 1924) provided an interesting exception during the present season, for very few bines wilted before picking. This amelioration of the disease was correlated with a soil structure enabling the early disposal of the excessive spring water from the winter rain, and consequently under the dry supervening summer conditions the water-table remained at a considerable distance below the level of the soil during the entire growing season.

Bacterial Diseases of Fruit Trees.

Bacterial Canker, caused by *Pseudomonas mors-prunorum*, in plum and cherry trees was apparently less severe in 1937 than in 1936 as fewer enquiries were received concerning it. One grower sending specimens from Durham said that out of 200 plum trees thirty had lost branches and one had died completely ; the trees affected were all Victoria, except one Farleigh Damson.

Bacterial Fruit Spot is not of frequent occurrence on either cherries or plums, even on trees showing severe leaf spot. On plums it had not been seen since 1926 until 1937 when one Victoria plum bearing two spots was found on one of the trial plots on the Station. *Pseudomonas mors-prunorum* was isolated from the spots.

Bacterial Blossom Blight of pears, mentioned in the Report for 1936, was found on a number of varieties—Conference, Dr. Jules, Doyenne du Comice, Glou Morceau, and Pitmaston Duchess. Specimens showing the disease were received from three localities in Kent.

Virus Diseases of Strawberry.

In 1937 the symptoms of Mild Crinkle and Severe Crinkle became clearly evident from the latter end of April onwards.

With Yellow-edge, however, although certain severe cases could be identified by the middle of May, conditions on the whole remained unfavourable for the full development of symptoms until the latter end of September.

Summary.

Certain non-parasitic, fungal, bacterial, and virus diseases observed during 1937 on fruit trees and bushes are noted. Among the more unusual diseases are Blotchy Pit (a functional disease of apples), Wither Tip of Morello cherry (*Sclerotinia laxa*), Hawthorn Leaf Blotch (*Sclerotinia Cydoniae*), Verticillium Wilt of Quince stocks (*V. Dahliae*), Cherry Leaf Curl on Morello cherry (*Taphrina minor*), Coral Spot Canker of a cordon apple tree (*Nectria cinnabarina*), Verticillium Wilt of Strawberry (*V. Dahliae*) and a severe outbreak of Grey Mould of strawberry fruits (*Botrytis cinerea*).

THE CROWN GALL DISEASE OF NURSERY STOCKS

III. A PROGRESS REPORT ON EXPERIMENTS FROM 1929 TO 1937 TO DETERMINE THE RELATIVE SUSCEPTIBILITY OF MALLING APPLE STOCKS AND INCLUDING THE PRODUCTION OF GALLS BY SYNTHETIC GROWTH SUBSTANCES

By R. V. HARRIS and H. L. PEARSE

INTRODUCTION.

These experiments were primarily undertaken to determine by artificial inoculation under controlled conditions the relative inherent susceptibility to Crown Gall of varieties of vegetatively propagated apple rootstocks. In the first (1929) experiment of the series (4) two varieties of stock (Nos. II and VII) were compared in the following respects :

(1) The proportion of inoculated trees developing galls, and

(2) Possible differences in rate of growth between inoculated trees with galls and inoculated trees without galls.

On the second basis of comparison it was concluded that under the conditions of the experiment the bacterium had no effect on the growth of either stock during the year of inoculation. As however the validity of this conclusion was based on the assumption that the inoculations which did not result in a gall had completely failed, a series of non-inoculated (but comparably wounded) control trees was introduced into the subsequent experiments, started in 1930, 1935 and 1937 respectively. A further complication possibly affecting the validity of conclusions under the first of the above criteria of " susceptibility " became apparent in the 1935 experiment. In this experiment " layer " stocks (i.e. stocks detached from the stool immediately before use) were substituted for the " one-year-bedded stocks " used in the previous experiments. Many of the trees were therefore relatively poorly provided with roots at the time of potting, and were still apparently dormant when inoculated in May. The percentage of these trees ultimately producing galls was found to be much below that of the trees which were in leaf at the time of inoculation. This applied, of course, solely to those varieties of stock which normally break dormancy earliest in the season, all the trees of such stocks as No. XVI being comparatively dormant when inoculated. It was therefore evident that the percentage of trees of any one stock developing galls might vary with the time of inoculation in relation to the dormant period peculiar to that stock.

Each of the original criteria of " relative susceptibility " having thus been shown to be open to question and qualification in certain respects, the scope of the more recent experiments was therefore enlarged to explore the following points :

(1) Does a successful parasitism of the tree by *B. tumefaciens* necessarily result in the formation of a gall ?

(2) What are the symptoms of the Crown-gall disease other than the production of galls, and how are these symptoms related to gall-production ?

(3) How is " time of infection " related to each of the above questions ?

Brown and Gardner (1, 2) have shown that galls can be produced on a number of different species of plants by applying lanolin pastes of indoleacetic acid or indolepropionic acid to wounded stems, and further that a substance extracted with peroxide free ethyl ether from cultures of *B. tumefaciens* is also active when applied similarly. Kraus, Brown and Hamner (5), Hamner and Kraus (4) and Link, Wilcox and Link (6) have confirmed these results using notably plants of bean (*Phaseolus vulgaris*) and tomato (*Lycopersicum esculentum*). Link and others (6) claim to have shown that indoleacetic acid is produced by cultures of *B. tumefaciens* especially when grown in dextrose-tryptophane or in dextrose-tryptophane-peptone liquid or agar media, and the fact that Němec (7) observed that the rooting of cuttings was stimulated by the application of smears of *B. tumefaciens* lends additional support to the view that under suitable conditions this organism produces a growth substance, since the promotion and acceleration of root formation is one of the well-known characteristics of these substances. A series of " inoculations " with synthetic growth substances was therefore included in the 1937 experiment with the object of observing if analogous galls could be produced on apple stocks by this means, and if so whether the relation between gall-formation and the state of the host was identical for galls thus produced and those produced by bacteria. It was hoped by this means to obtain information (*a*) upon the factors influencing gall production, and thence (*b*) upon the causes of the high variability in the results of inoculation with *B. tumefaciens*. In this present progress report it is proposed briefly to indicate the more salient of the results of these experiments to date.

Experiments started in 1929, 1930, 1935.

Incidence of Galls.

In each of these experiments exactly comparable sets of trees in pots, of each stock under test, were inoculated with pure cultures of *B. tumefaciens* during the month of May, the method and inoculum* being in all cases as described in the account of the 1929 experiment (4).

Table I.

Stock.	Percentage of Galled Trees.		
	Inoculated 9–5–29.	Inoculated 12–5–30.	Inoculated 20–5–35.
I.	19	14	13
II.	—	51	29
VII.	46	28	22
XVI.	—	0	3

Table I shows the percentage of trees of each stock producing galls after inoculation.† It will be noted that although the percentage of galled trees for any one stock varies considerably, the relative susceptibility of the four stocks (on this basis of

* The strain used was isolated from a raspberry gall in 1926 by Dr. H. Wormald.

† The results bearing on the size of the galls are deferred to a future communication.

measurement) was the same for each experiment, i.e. No. II was the most susceptible, followed closely by No. VII. No. I was comparatively resistant, and No. XVI showed almost complete immunity.

As indicated above " layer " stocks were used for the first time in the 1935 experiment, and as a result half only of the inoculated No. II trees were coming into leaf at the time of inoculation. The 30 per cent. galled trees recorded for this stock in Table I is calculated from these leafed trees alone ; 12 per cent. only of the surviving dormant trees produced galls, indicating that the production of galls was related to the stage of tree development at the time of inoculation. The 1937 experiment was planned to explore this point further.

Effect of Inoculations on Tree Growth.

Uninoculated " control " trees were introduced into the 1930 experiment for No.VII stock alone, and into the 1935 experiment for each of the four stocks under comparison. These and the inoculated trees were treated similarly except that the bacterium was not introduced into the control trees.

1930 *Experiment.* At the end of the first season after inoculation, the growth of the inoculated No. VII trees was found not to differ significantly from that of the control trees. The trees were then transferred from the pots to the open ground, and further records made at the end of the second growing season (1931) showed that the growth of the inoculated trees was significantly *less* than that of the control trees. This difference in growth was not related to the production of galls on the inoculated trees, i.e. both the galled and non-galled *inoculated* trees received a check.

1935 *Experiment.* Here the trees were allowed to remain in pots during the 1935 and 1936 seasons. Records made at the close of the latter season showed that the growth of the inoculated trees of both No. VII and No. XVI stocks was significantly *greater* than that of the control trees. As in the previous experiment this effect was equally apparent on the trees with and on those without galls.

1937 Experiment.

Comparable series of Malling stocks Nos. II, VII and XVI were inoculated on 2nd April and on 15th June respectively. It was originally intended that the first of these series of inoculations should be made when all the stocks were completely dormant. Owing to difficulties in obtaining active cultures of the inoculum it was necessary to postpone the early inoculation until 2nd April, at which time stocks Nos. II and VII were just beginning to move. No. XVI, however, was apparently still dormant at this time.

In addition to *B. tumefaciens* a parallel series of " inoculations " was made on both dates using a lanolin paste containing 2 per cent. indolebutyric acid. Roughly 10 mg. of paste was applied for each inoculation. A small number of trees were also " inoculated " at the later date with a similar amount of 1 per cent. α-naphthalene acetic acid. The procedure adopted was the same as for the bacterial inoculations and with very few exceptions large galls were produced by both substances remarkably uniform in size, and closely resembling crown-galls in external appearance. The bacterial galls however usually projected further from the stem, and were more constricted at the point of attachment, and were therefore more readily detachable. (See Photograph.)

TABLE II.

Date of Inoculation.	Root-stock.	Treatment.	No. Trees.	% with galls.	Mean volume of gall, c.c.	Coefficiency of variability in size of galls.
5–4–37	II.	B. tumefaciens ..	25	40	2·6	42
	VII.	,, ..	25	68	1·4	35
	XVI.	,, ..	25	0	—	—
15–6–37	II.	,, ..	25	72	1·7	41
	VII.	,, ..	25	68	1·6	36
	XVI.	,, ..	25	20	1·1	18
5–4–37	II.	2 % indolebutyric acid paste ..	10	90	1·8	29
	VII.	,, ..	10	90	1·7	13
	XVI.	,, ..	10	20*	1·1	—
15–6–37	II.	,, ..	10	90	2·4	13
	VII.	,, ..	10	100	2·1	17
	XVI.	,, ..	10	100	2·0	8

* 5 trees dead and 3 badly cankered ; the two remaining trees had galls.

Incidence of Galls.

This is fully summarized in Table II where the following points may be noted :

(1) The June inoculations with *B. tumefaciens* of stocks Nos. II and XVI produced more galled trees than those made in April.

(2) On the basis of the June inoculations with *B. tumefaciens* the stock varieties conform to the order of " relative-susceptibility " previously determined. It must be noted however that the percentage of galls on No. XVI considerably exceeded that in the earlier experiments.

(3) The " inoculations " with 2 per cent. indolebutyric acid, and with 1 per cent. α-naphthalene acetic acid with very few exceptions resulted in the production of galls irrespective of the variety of the stock inoculated and the time of inoculation. The April inoculation of stock No. XVI provided an exception, when inoculating with indolebutyric acid at the concentration used was clearly lethal to most of the trees in this set. The data for α-naphthalene acetic acid are not included in Table II as the unit consisted of only five trees.

(4) The variability in size of the bacterial galls markedly exceeded that of the galls from the synthetic substances.

Effect of Inoculation on Tree Growth.

Owing to the relatively small units of trees for each treatment and their high degree of variability further experiments will be necessary before the results can be completely evaluated. Meanwhile the following may be noted :

(1) The mean growth rate on the basis of fresh weight per tree for each of the three stocks inoculated with *B. tumefaciens* (on one or the other of the two dates of inoculation) was significantly greater ($P = 0 \cdot 05$) than that of the uninoculated control trees.

(2) Conversely the mean growth rate of the trees of No. II stock inoculated with growth substance on each of the two dates was significantly *less* than that of the control trees.

Discussion.

Following each series of inoculations with *B. tumefaciens* (completed on a single date) a fraction only of the inoculated trees developed galls, the proportion varying for each variety of rootstock. On this basis of comparison the stock varieties formed a constant series in order of " apparent susceptibility ". The response of each rootstock to this disease (i.e. in terms of percentage galled trees) was also found to vary according to whether the inoculations were made early or later in the season. When indolebutyric acid paste was used the variability both in the percentage of trees with galls, and in gall size, was markedly reduced ; with very few exceptions galls of uniform size developed on all the inoculated trees irrespective of the stock variety, and the date of inoculation. Clearly, then, at each date, given the presence of an active substance, the host will respond by the production of a gall, and therefore the failure of the bacterium to produce a gall is probably explained by its failure to produce the substance, and this depends upon the physiological condition of the host. Possible explanations of this failure are (*a*) inability of the organism to grow because of unsuitable conditions in the host, or (*b*) growth of the organism without the production of the active gall-forming substance. Since, however, the organism affects the growth of the host even though a gall is not produced, the latter explanation would seem more likely, and the failure to produce a gall may possibly be due to the absence in the host of an inactive precursor substance A, from which the organism can produce the active gall-forming substance B. One such precursor substance might be tryptophane since it is well known that one of the stages in its decomposition is indoleacetic acid.

In this connection, it is significant to note that Link and others (6) obtained most active gall-forming extracts when the bacterium was growing on a medium containing tryptophane. The relative susceptibility of the rootstocks as measured by gall formation may therefore depend on the presence or absence of the inactive precursor substance.

The inoculations with *B. tumefaciens* had a measurable effect on the growth of the host trees irrespective of the formation of galls, and this effect also varied with the time of inoculation and the variety of rootstock. The inoculations with indolebutyric acid caused a significant depression in the growth of stock II but was without effect on the other two varieties. Hamner and Kraus (3) working with *Phaseolus vulgaris* found that the presence of tumours formed by growth substances brought about little or no retardation of the growth of the stems, and the plants fruited as well as plants which had not been treated. The fact that the presence or absence of the gall bears no clear relation to the effect of the organism on the growth rate of the host would seem to indicate that the conditions affecting the growth of the gall are distinct from those produced by the organism and affecting the growth of the host*.

A further point which is not yet clear is whether the initial amount of growth substance applied bears any relation to the subsequent growth of the gall. It is well known that the normal hormone production in the plant is a continual process of formation, and destruction in the process of growth, and Pearse (8) has shown that to obtain a continued growth response of tomato plants (*Lycopersicum esculentum*) to applied phenylacetic acid, or indolebutyric acid renewed applications are necessary. The question therefore arises as to whether the subsequent growth of the gall is affected by the initial amount of growth substance applied or whether after the initial stimulus the gall itself in the process of its growth produces substances necessary for its further growth. Thus attempts to isolate the bacterium from galls are frequently

* Thus organisms isolated from apple-galls at East Malling and culturally answering closely to *B. tumefaciens* have consistently failed to produce galls but, on the other hand, have stimulated the growth of the inoculated trees, as with the isolants from raspberry.

unsuccessful even though the gall is still actively growing. The conditions necessary for the subsequent growth of the gall may therefore be quite independent from those which caused its initiation.

In further experiments which have now been started, it is hoped to throw further light on some of these points. These experiments will include periodic inoculations of trees at monthly intervals, (*a*) with strains of *B. tumefaciens* isolated from different hosts, (*b*) with extracts from pure cultures of *B. tumefaciens* growing on different media, and isolated from various hosts, and (*c*) with synthetic growth substances in varying concentrations.

Summary.

1. The percentage of trees of various varieties of the Malling apple rootstocks forming galls after inoculation with *B. tumefaciens* varied with the type of rootstock. On this basis, Malling No. II was the most susceptible, followed closely by No. VII. No. I was comparatively resistant, and No. XVI showed markedly high resistance.

2. The percentage of trees forming galls varied with the physiological state of the host. In general galls were formed more readily when inoculations were carried out after the dormant period.

3. The inoculations with *B. tumefaciens* had a measurable stimulating effect on the growth of the host trees of each type of rootstock, and irrespective of the formation of galls, and the magnitude of this effect also varied with the time of inoculation and the variety of rootstock.

4. Parallel " inoculations " with 2 per cent. indolebutyric acid in lanolin caused gall formation irrespective of the variety of rootstock, and the time of inoculation. With very few exceptions large galls were produced, remarkably uniform in size, and closely resembling crown-galls in external appearance.

5. The " inoculations " with indolebutyric acid were without effect on the growth of trees of rootstocks Nos. VII and XVI ; but caused a significant depression in the growth of trees of No. II.

6. It is suggested that the failure of the organism to produce galls is probably due to its failure to produce an active gall-forming substance, this depending upon the physiological state of the host.

7. The effect on the growth of the host is not linked with the presence or absence of a gall or with gall size, and it is suggested that the etiological factors affecting the growth of the host are distinct from those determining the initiation of a gall.

Literature Cited.

(1) Brown, N. A. and Gardner, F. E. " Galls produced by plant hormones, including a hormone extracted from *Bacterium tumefaciens*." Phytopath., 1936, **26**, 708-13.

(2) ——— " Indoleacetic Acid Galls of a Secondary Type." Phytopath., 1937, **27**, 1,110-13.

(3) Hamner, K. C. and Kraus, E. J. " Histological Reactions of Bean Plants to Growth Promoting Substances." Bot. Gaz., 1937, **98**, 733-807.

(4) Harris, R. V. " The Crown Gall Disease of Nursery Stocks. II. The Relative Susceptibility of Apple Stocks to Crown Gall." E. Malling Res. Stn. Ann. Rep. for 1928-30 (1931), 140-2.

Galls produced on Malling No. II stock by inoculations in June 1937 with (1) *B. tumefaciens* and (2) 2 % Indolebutyric acid in lanolin. *Photo. February* 1938.

(5) Kraus, E. J., Brown, N. A. and Hamner, K. C. "Histological Reactions of Bean Plants to Indoleacetic Acid." Bot. Gaz. 1936, **98**, 370-420.

(6) Link, G. K. K., Wilcox, H. W. and Link, A. D. "Responses of Bean and Tomato to *Phytomonas tumefaciens*, *P. tumefaciens* extracts, β-indoleacetic acid, and Wounding." Bot. Gaz. 1937, **98**, 816-67.

(7) Němec, B. "Bakterielle Wuchsstoffe." Ber. d. bot. Ges. 1930, **48**, 72-4.

(8) Pearse, H. L. "The Effect of Phenylacetic Acid and Indolebutyric Acid on the Growth of Tomato Plants." Journ. Pom. and Hort. Sci. 1937, **14**, 365-75.

MANURIAL TRIAL ON NURSERY TREES WITH REFERENCE TO EFFECT ON PLUM BACTERIAL CANKER

By H. WORMALD and R. J. GARNER

Bacterial Canker is one of the most destructive diseases in plantations of plum and cherry trees (2, 4), and no really satisfactory measures for preventing it have yet been found, though some degree of control can be obtained by spraying, and by avoiding injury to the trees during the critical period in autumn when the stems and branches become infected. One possible way of approaching the problem is by attempting to build up resistance in the trees by applying suitable fertilizers to the soil. There is the question, for instance, of whether the application of potash, which is so often present in insufficient quantity for satisfactory growth of fruit trees, may tend to induce resistance. Previous experiments (3) have yielded little hope that control can be affected by any simple modification of ordinary farm practice so far as manuring is concerned, but it was thought desirable to carry out a further trial on a more extended scale and on randomized plots. Dressings of hydrated lime were included in this experiment as it has been suggested that deficiency of lime may be a factor inducing susceptibility to Bacterial Canker.

A strip of ground 312 feet long by 2 feet wide was marked out for this purpose, and divided into twenty-four plots, each 11 feet long with 2 feet between adjacent plots. It was decided to plant each plot with twelve trees, of which the one at each end was to be a buffer. In order that the trees would be as uniform as possible they were all to be on the same rootstock, and the scions all of one variety. In January, 1932, therefore, the plots were planted with Myrobolan B as one-year-olds from a clonal layer bed, and in July the same year they were budded with Victoria.

For the various treatments the whole strip was divided into three equal parts each of eight plots, for eight different treatments. These treatments were so designed that the plots should receive nitrogen, phosphorus, or potassium, or combinations of these. Thus the eight plots received **0** (Control), N, P, K, NP, NK, PK, NPK, the distribution being randomized. The nitrogen was applied as sulphate of ammonia, the phosphorus as superphosphate of lime, and the potassium as sulphate of potash. The treatments were thus primarily in triplicate but on the eight plots forming the middle third of the strip were superimposed dressings of lime.

As each plot occupied 22 sq. feet, 1 oz. per plot was considered to be the approximate equivalent of 1 cwt. per acre. The applications therefore were as follows :

Fertilizer.	Rate per acre.	Amount per plot.	When applied.
Sulphate of ammonia ..	2 cwt.	2 oz.	April-May.
Superphosphate	5 cwt.	5 oz.	Feb.-April.
Sulphate of potash	4 cwt.	4 oz.	Feb.-April.
Hydrated lime	2 tons.	2½ lb.	June-July.

These applications were made each year from 1932 to 1935 inclusive.

In October, 1933, all the trees were inoculated from a pure culture of *Pseudomonas mors-prunorum*, the organism causing Bacterial Canker of plum trees. The bacterial slime from an agar culture was transferred to a flask of sterile water to form a rather cloudy suspension. A Λ-shaped cut was made through the bark near the middle of the stem ; the triangular portion was turned back and a drop of the suspension inserted, the tongue of bark being then pushed back into its position. The trees were all inoculated on the same day.

During the following summer the trees were examined and it was found that although cankers had arisen at the inoculated spots they were mostly no longer than about 2 cm., and the longest measured only 10 cm. (4 inches).

The trees were therefore inoculated again on 24th October, 1934. When examined in 1935 the resulting cankers again were found to be mostly very small and measurements were not taken. This result was somewhat surprising in view of the fact that certain plum trees used in another experiment (trees in sand cultures in pots) were inoculated about the same time in a similar manner with the same strain of the organism, and on many of these trees long cankers developed, some of them girdling and killing the trees (1). It would appear then that the physiological condition of the trees in the strip of ground was such as to prevent severe infection and the results suggest that the soil conditions throughout the plots were in some way conducive to resistance, or that the dormancy period of the trees was not sufficiently advanced for infection to be really effective. The latter appears to be the more likely explanation for the trees in pots, referred to above, had shed their leaves earlier in the season than the trees in the present experiment, and again the inoculations made at a later date the following year were successful.

Another factor which may have some bearing on the degree of infection following inoculation, is the weather in autumn. In 1933 and again in 1934 the rainfall in October and November was below the average, while in November, 1935, the rainfall was considerably above the average, and in this connection it may be remarked that the outbreaks of Bacterial Canker in commercial plantations in 1936, following the wet autumn, were exceptionally severe.

The trees were once more inoculated, about the middle of November, 1935, and examined the following summer. It was then found that well-developed cankers had arisen on many of the trees as a result of the inoculations, so each canker was measured. Every inoculation had given rise to a canker ; some of these cankers were quite short, no more than 2 cm. in length, but others were of considerable length, the longest measuring 58 cm. (nearly 2 feet), and several had girdled the stems and killed the trees. The results obtained are summarized in Table I, the range in length from the shortest to the longest canker on each plot being given. The cankers on the buffer trees, which were also inoculated, are not included, and, as a few of the trees did not grow out from the buds or died later from some cause other than as a result of inoculation, the trees recorded for cankers on each plot were from eight to ten in number.

It will be seen that on each plot, with the exception of Plots 23 and 24, there is wide variation in the size of the cankers. At present the reason for this is unexplained, since all the trees were inoculated on the same day and as uniformly as possible, using drops of the same bacterial suspension. The figures were submitted to Mr. T. N. Hoblyn for a statistical examination but no really significant differences in the results of the various treatments could be found. The only treatment with results approaching significance was in relation to the middle set of eight plots (9 to 16), which received lime, as compared with those not receiving lime (1 to 8, and 17 to 24). In six of the limed

TABLE I.

SHOWING THE DISTRIBUTION OF THE PLOTS AND RESULTS OBTAINED IN EACH.

Plot No.	Treatment.	Range in length of cankers in cm.	No. of trees killed.	Average length of cankers in cm.
1	N	6–38	2	16
2	K	3–31	0	7
3	NPK	2–11	0	6
4	**0**	2–32	1	13
5	P	4–30	0	10
6	PK	5–27	0	11
7	NK	3–27	0	9
8	NP	2–29	1	14
9	PK + Ca	4–34	2	21
10	**0** + Ca	3–31	1	14
11	P + Ca	3–30	0	15
12	NK + Ca	6–31	1	14
13	NP + Ca	4–15	0	9
14	N + Ca	4–13	0	8
15	K + Ca	4–28	0	14
16	NPK + Ca	3–58	1	21
17	K	3–28	0	12
18	P	3–32	1	15
19	NP	3–22	0	10
20	**0**	3–24	0	7
21	NK	3–41	0	8
22	PK	3–46	0	12
23	NPK	2–7	0	4
24	N	3–6	0	4

TABLE II.

AVERAGE LENGTH OF CANKERS IN CM. ACCORDING TO MANURIAL TREATMENT OF TREES.

Plots.	**0**	N	P	K	NP	NK	PK	NPK	Average per 8 plots.
1-8	13	16	10	7	14	9	11	6	11
9-16 (with lime)	14	8	15	14	9	14	21	21	14
17-24	7	4	15	12	10	8	11	4	9
Average per treatment ..	11	9	13	11	11	10	15	10	

plots the average length of the cankers was greater than that for the corresponding plots which did not receive lime, as shown in Table II. The most striking difference is seen in the two plots receiving NPK (average length of cankers 6 and 4 cm. respectively), and that receiving the same with the addition of lime (with cankers averaging 21 cm.).

On the whole then it may be said that not one of the treatments reduced susceptibility to Bacterial Canker to any significant extent, and the results offer little hope of control by any special application of artificial fertilizers. Moreover, there is no evidence that dressings of lime reduce susceptibility to this disease; in fact the results suggest an opposite effect, especially when the lime is used in combination with balanced dressings consisting of sulphate of ammonia, superphosphate and sulphate of potash. It will

be noticed, however, that such a balanced fertilizer without the lime has given the most consistent low figures for cankers.

We are greatly indebted to Mr. T. N. Hoblyn for his assistance in planning this experiment and for examining the figures relating to the results obtained.

Summary.

An experiment is described in which randomized plots of young plum trees received various manurial treatments. The trees were then inoculated with *Pseudomonas morsprunorum*, the organism causing Bacterial Canker of plum trees, and the size of the resulting cankers recorded.

No significant differences could be found in the results obtained, but there is a suggestion that applications of lime tend to induce susceptibility.

References.

(1) Beard, F. H. and Wormald, H. "Bacterial Canker of Plum Trees in Relation to Nutrition. Experimental Results in Sand Cultures (with an appendix by W. A. Roach)." E. Malling Res. Sta. Ann. Rep. for 1935 (May, 1936), 146-54.

(2) Wormald, H. "The Symptoms of Bacterial Canker in Plum Trees." Journ. Pom. and Hort. Sci., 1931, **9,** 239-56.

(3) ——— "Some Field Observations and Experiments on Plum Bacterial Canker." E. Malling Res. Sta. Ann. Rep. for 1933 (May, 1934), 147-53.

(4) ——— "Field Observations on Bacteriosis of Sweet Cherry Trees." Journ. Pom. and Hort. Sci., 1937, **15,** 35-48.

TWO ORNAMENTAL SHRUBS AS HOSTS OF THE ORGANISM CAUSING PLUM BACTERIAL CANKER

By H. WORMALD

Observations in plantations, and inoculation experiments, have shown that bacterial cankers in plum and cherry trees arise from infection of the stems and branches in autumn. For this reason trees may be actually infected in the later months of the year without showing any obvious signs of the disease until the following spring or summer. In experiments where stems have been inoculated in October or November no trace of disease has been visible externally until the trees have started to come into leaf in the spring. If then trees show the symptoms of Bacterial Canker during the first season after they are planted up it is to be suspected that they were already infected when taken from the nursery, and it is probable that nurserymen do at times send out infected nursery trees without having any suspicions that such trees may be carrying disease, since there are no external symptoms at the time of lifting to indicate that they are infected.

Infection of nursery trees must therefore receive serious consideration and, in fact, is receiving the attention of those nurserymen who endeavour to keep their trees free from disease, so that the stocks they send out are healthy not only in appearance but in fact.

The symptoms of Bacterial Canker in plum and cherry trees have been described from time to time ; nurserymen should be on the watch for such symptoms and take steps to check any outbreak of the disease. It should be borne in mind too that the organism *Pseudomonas mors-prunorum*, which is chiefly responsible for Bacterial Canker in this country, is able to attack not only plum and cherry trees but other species of Prunus also. It has been isolated from lesions on peach, cherry plum (Myrobolan), and Morello cherry. More recently it has been found associated with disease in ornamental shrubs, and the present paper describes its occurrence on the Almond (*Prunus Amygdalus*) and the Purple-leaved Plum (*P. Pissardii*).

Bacteriosis of Almond (*Prunus Amygdalus*).

In May, 1936, Mr. W. Buddin, Advisory Mycologist at the University of Reading, sent me the terminal portions of some maiden trees of the common single pink almond which he had obtained from a nursery in Berkshire. He informed me that the buds had started to grow out and then withered at all distances along the maiden stem ; this was accompanied by a dying back of the shoots, and in places gum oozed out from infected stems.

The portions of stems examined were dead at the tips for a length of from 2 to 9 inches, and below the dead tips on some specimens were withered shoots at various levels. On some of the specimens there were discoloured areas on the stems round about the nodes, suggesting that lesions had started on the shoots and then extended from these into the stems.

On the green shoots some of the leaves bore irregular blotches and spots more or less circular in outline. Each spot had a dark brown centre with a pale green zone

surrounding it. The isolated spots were 1-2 mm. in diameter and the irregular blotches were apparently caused by several spots coalescing.

Microscopic examination of the girdling stem lesions showed dense masses of bacteria in the cortical region at the lower end of the lesion bordering on the healthy tissues. Similar bacterial masses were present in the tissues of the isolated dead shoots, in the stem lesions round the bases of such shoots, and in the leaf-spots.

The presence of bacteria in such quantities suggested that the trouble had been brought about by bacterial infection. Culture plates were prepared, therefore, using as the culture medium nutrient agar containing 5 per cent. cane sugar, a medium which had been found to be suitable for isolating the bacteria which attack plum and cherry trees, and bacteria were isolated from lesions on stems, shoots and leaves. All produced similar looking colonies ; the structure of these colonies and their rather slow rate of growth suggested that the organism was identical with that causing Bacterial Canker in plum trees and known as *Pseudomonas mors-prunorum.*

Other cultural tests were applied which confirmed the identity of the organism, and later, inoculation experiments were carried out on plum trees with the organism isolated from almond, and cankers developed as a result (see below).

Bacteriosis of the Purple-leaved Plum (*Prunus Pissardii*).

In August, 1936, a portion of a stem of a Purple-leaved Plum tree which had recently died was received from the Swanley Horticultural College, Kent. The specimen was examined by Mr. M. H. Moore who found that the stem had been girdled by a canker and that numerous bacteria were present in the discoloured bark. Culture plates were prepared and an organism isolated which again appeared to be *Pseudomonas mors-prunorum.* Cultural tests and inoculation experiments were therefore carried out, with results similar to those obtained with the organism isolated from lesions on the almond.

The stem was the only part of the tree available for examination and it is not known whether the cankering in this case was associated with spotting of the foliage such as was noted in the almond.

Inoculations on Plum Trees.

The evidence offered by the cultural tests was that the organisms isolated from Almond and from the Purple-leaved Plum were in all probability identical with the one known to cause Bacterial Canker in plum trees, but it was deemed necessary to carry out inoculation experiments in order to ascertain whether the strains isolated were indeed able to cause infection. Material of Almonds and Purple-leaved Plum was not available for this purpose so the inoculations were carried out on young Victoria plum trees.

The inoculations were made on 4th November, 1936, on a row of sixteen trees. Four of these were inoculated with the organism from *Prunus Pissardii*, four with a strain from a leaf-spot of almond, four with a strain from almond stem, and four trees were left as controls. Each tree was inoculated at two places by making Λ-shaped cuts in the bark and inserting in each cut a drop of a suspension of the organism in water. On the control trees sterile water only was placed in the cuts.

The trees were examined the following summer when it was found that cankers had developed round all the inoculated cuts and that the wounds on the control trees had healed normally with no cankering whatever. None of the cankers had completely girdled the trees, although on each of two trees one canker extended three-quarters of

the distance round the stem. On the average the cankers produced by the strain from *Prunus Pissardii* were rather longer than those induced by the almond strains, as shown in the Table. The largest cankers were about 8 inches long.

Results of Inoculations.

Source of strain.	Range in length of cankers in cm.	Average length of cankers.
Prunus Pissardii stem	11-21	15
Almond leaf-spot	6-22	11
Almond stem	9-15	11

All three strains are thus found to be able to infect plum trees and the results show, therefore, that the Almond and the Purple-leaved Plum may serve as hosts for the organism which causes Bacterial Canker of plum trees.

It is possible that other species of ornamental shrubs of the genus *Prunus* are also susceptible to bacterial infection by the same organism, and any such plants which show leaf-spots, wilted shoots, or cankered stems, should be examined to ascertain whether the lesions contain bacteria.

My thanks are due to Mr. W. Buddin and to Dr. Barratt, Principal of the Swanley Horticultural College, for sending the specimens of Almond and Purple-leaved Plum respectively, and to my colleague Mr. M. H. Moore for his help in isolating the organism from the Purple-leaved Plum.

Summary.

Young Almond trees (*Prunus Amygdalus*) from a Berkshire nursery were found to have bacterial lesions on leaves, shoots, and stems.

A bacterial lesion was found also on a stem of the Purple-leaved Plum (*Prunus Pissardii*).

The organisms were isolated, and cultural and inoculation tests showed them to be identical with *Pseudomonas mors-prunorum*, the organism causing Bacterial Canker in plum trees.

Almond leaves with bacterial spots.

Almond maiden stem : shoots killed by bacterial infection.

Almond stem with a bacterial lesion and dead tip.

A BIBLIOGRAPHICAL NOTE ON THE DISTINCTION BETWEEN MILD AND SEVERE STRAWBERRY CRINKLE

By R. V. HARRIS

" CRINKLE " was first described as a virus disease of strawberries by Zeller and Vaughan in the U.S.A. in 1932 (4), and a year later Zeller gave a somewhat amplified account of the disease (5). In the latter (p. 5) he remarked : " Since some plants show more severe symptoms than others under like environmental conditions, we are led to believe that there may be separable components of the virus, one producing more severe symptoms, and another what might be termed a ' mild crinkle.' "

What was considered to be the same disease was first described in England by Ogilvie, Swarbrick and Thompson (3) in 1934. The disease was later found at East Malling, and was shown to be a virus disease transmissible by runner grafting (1).

In 1935 Harris discovered that Royal Sovereign plants which had hitherto been regarded as " normal " were in reality infected with a virus (2). The symptoms produced by this virus were very mild in character, consisting primarily of minute, translucent chlorotic spots later developing reddish or purplish centres. The latter symptoms corresponded exactly with those described by Zeller (5) (p. 5) as the " primary symptoms " of " Crinkle ", and later by Ogilvie *et al.*, and the symptoms in their entirety agreed closely with those referred to by Zeller (*ibid.*) as characteristic of " mild crinkle ".

Harris found that the wild strawberry (*Fragaria vesca*) was a sensitive indicator for the presence of the mild virus. From numerous grafting tests, in which this species was used as indicator plant, he concluded that the mild virus was widely distributed in certain Royal Sovereign stocks in the south of England.* Massee also showed in 1937 that the strawberry aphis, *Capitophorus fragariae* Theob., is a vector of this virus. (See present Report, p. 98.)

The disease produced by this virus, now referred to as " mild crinkle ", is commonly so inconspicuous that it is not noticed by the grower. Nevertheless, cases are not infrequently observed in which the symptoms are rather more pronounced, and it may then be difficult to say whether a plant represents a relatively severe case of " mild crinkle " or a mild case of " severe crinkle ". There is no doubt, however, that the " mild crinkle " virus is widely distributed in areas where " severe crinkle " is of comparatively rare occurrence.

As regards the relation between " mild crinkle " and " severe crinkle ", existing data, although confirming Zeller's suggestion that these diseases are etiologically distinct, are not sufficient as yet to enable a decision to be made on the nature of their association. There are at least two possibilities : (1) That this association is fortuitous —i.e. that " severe crinkle " is due to a definite virus which could act independently of that of " mild crinkle ". On this hypothesis the fact that the two are usually found in association would be explained by the comparatively wide distribution of the " mild crinkle " virus. (2) That the association is obligatory—i.e. that the " mild crinkle "

* A detailed account of these experiments is in preparation for publication.

virus is an essential constituent of " severe crinkle ". On this hypothesis, when a plant infected with the " mild crinkle " virus becomes infected with a certain other, as yet undetermined or unisolated, virus the " severe crinkle " disease would result. " Severe crinkle ", in other words, would be a disease resulting from infection with two viruses.

As the available data, although perhaps favouring the latter hypothesis, are as yet inconclusive, it is proposed provisionally to retain the designations " mild crinkle " and " severe crinkle ", bearing in mind, however, that an etiological distinction is now implied, the precise nature of which remains to be determined.

Summary.

Available data on the strawberry virus diseases known as " mild crinkle " and " severe crinkle " are summarized, with special reference to the nature of the relationship between these diseases.

References.

(1) Harris, R. V. E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 212-21.

(2) ——— E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 201-11.

(3) Ogilvie, L., Swarbrick, T. and Thompson, C. R. Long Ashton Res. Sta. Ann. Rep. for 1933 (1934), 96-7.

(4) Zeller, S. M. and Vaughan, E. K. Phytopath. **22,** 709-13, 1932.

(5) Zeller, S. M. Agric. Exper. Sta. Oregon State Agric. Coll. Bull. 319, 1933.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED ON FRUIT TREES IN 1937

By A. M. MASSEE

1. *Sinodendron cylindricum* L.

This species of Lamellicorn beetle occurs commonly in the South of England, and its larva may be found tunnelling into the trunks of ash, beech, elm, willow, oak, etc. It is usually associated with unhealthy trees, for example, those in a state of decay, and even rotten logs.

In addition to the above hosts this beetle was found infesting the trunks of some cherry trees in an orchard at Tenterden, Kent. Some of the attacked trees appeared to be quite as healthy as the uninfested ones. Others, however, were sufficiently unhealthy to justify grubbing them, and a later examination showed that the trunks were badly infested with the larvae of this beetle. Adults were present also.

2. *Derocrepis rufipes* L.

An interesting record of the occurrence of this species of flea beetle feeding on apple foliage was noted near Faversham, during the latter part of June. The adults, which were in great profusion, were feeding on the young leaves at tips of the new growths. Most of the feeding was on the upper surface of the leaf. As the leaves expanded little holes developed at the points where the beetles had been feeding, the damaged leaves showing characteristic injury, similar to that caused to hop leaves by the Hop Flea Beetle.

The more usual host plants of this Chrysomelid beetle are the mallow and various leguminous plants, thus its presence on apple seems to be exceptional.

3. Shot Hole Borer (*Anisandrus dispar* F.).

The Shot Hole Borer is a familiar insect in apple and plum orchards where it may be seen boring into the trunks and branches of the trees. It also attacks pear and cherry.

During the latter part of May, 1937, numerous wood-boring scolytid beetles were found boring into the stems of several stools of Himalaya blackberry in a plantation at Kirdford, West Sussex. The current year's fruiting wood was attacked, the new growths being unaffected.

Stages of the beetles other than the adult were not noted, and it is considered that the infestation started during April, which is the flight period of the beetle.

The Shot Hole Borer is known to be a very common insect in West Sussex.

4. *Epipolaeus caliginosus* F.

The examination of partly decayed hop roots received from a hop grower at Tenbury, Worcestershire, in July, showed that a species of weevil larva was burrowing into the roots, making tunnels 6 inches or more in length. Some larvae were also boring into the apparently healthy roots as well. Adults emerged by the middle of August and the

species proved to be *Epipolaeus caliginosus* F. This insect has been associated with hops on only one occasion previously.*

So far it has not been ascertained whether this weevil is responsible for the failure of the hop hills concerned, but owing to the nature of the damage caused by the larva, there is probably some association.

The published records concerning this weevil are scanty. It is said to be a local species. The adult occurs under stones, in moss, etc., where it hides by day, coming out at dusk and during the night-time. According to Chapuis and Candèze† the larva is associated with Conifers and has been found in the galleries caused by *Hylobius* and *Pissodes*, which are two species of weevils familiar to all foresters.

In view of the above remarks it is not without interest to record this weevil tunnelling into the roots of hops.

5. *Librodor hortensis* Fc.

This Clavicorn beetle was noted on one of the apple plots at the Research Station in August and September. It was found feeding on the mummified fruits which were in a state of decay, but was not noted in the soft, rotten fruits.

The beetle usually occurs at the sap exuding from the bark of oak, fir, beech, etc., and it is not usually associated with apple trees or fruits.

Curiously enough it was not found on an apple dump in the same district.

The larva is said to be parasitic on other insects.

6. Brassy Tooth-legged Flea Beetle (*Chaetocnema consinna* Marsh).

The Brassy Tooth-legged Flea Beetle has been noted for several years feeding upon the leaves of strawberry, but it has not appeared in great numbers until 1937.

The adults were noted in August at Westerham and Biggin Hill and a little later on at East Malling, Kent.

This flea beetle feeds upon the upper surface of the foliage, usually selecting the younger leaves in preference to the older ones. The mode of feeding is very characteristic, since only the epidermal layers are removed, the under surface remaining untouched. The damage is very similar to that caused by the Apple Leaf Skeletonizer, but it is not so severe.

The normal host plants of this flea beetle are various species of dock, buckwheat and rhubarb. Hop used to be considered a host plant but this record appears to be an erroneous one.

7. Codling Moth (*Cydia pomonella* L.).

Evidence of second brood in this country.

Although the economic importance of the Codling Moth may vary from season to season, this pest is constantly in the minds of growers and scientists, since a severe outbreak may occur with little or no warning.

Now, while two or even more broods of this insect are known to occur annually in certain parts of the United States of America and elsewhere, there is little evidence to show that more than one brood exists in this country, although in some years it would appear that there is a partial second brood ; or alternatively that the first brood emerges over a very long period. In most seasons it is generally accepted that there is only one brood.

* Theobald, F. V., Entomologist, 1930, **63**, 3.

† Chapuis, M. F. and Candèze, M. E., Catalogue des Larves des Coléoptères, Liége, 1853, 547-8.

In 1937, however, definite evidence of at least a partial second brood has been obtained.

An experiment was in progress to determine the value of chemically treated corrugated cardboard bands for the control of Apple Blossom Weevil and Codling Moth to supplement routine spraying. In the course of this investigation, which involved weekly examination of the bands in the orchard, it was noted that Codling Moths were present from May until October, and this appeared to be a very long period for the emergence of only one generation.

When the bands were removed early in October numerous Codling Moth larvae were noted hibernating in them, and, in addition, a number of pupae very similar to those of the Codling Moth were noted also. Later on in the course of the survey of the bands, a number of empty pupal cases were found, and still more living pupae which appeared to be those of the Codling Moth or an allied species. Fortunately some moths hatched out from these pupae during the second week of October, and as anticipated they were typical specimens of the Codling Moth.

In the experiment, the bands were put on the trees in June, and it seems likely, therefore, that some of the first larvae to mature, left the fruits and wandered into the bands to pupate, and eventually emerged as a second brood in the latter part of September and early October.

The possibility of last season's larvae entering the bands the following June need hardly be considered, since once the larvae go into hibernation they remain there, without feeding, until the following spring, when pupation takes place, and finally the moths emerge from May onwards.

8. Tortrix-Larvae infesting Stored Apples.

During the last two seasons the damage caused by tortrix caterpillars has been particularly serious, partly on account of their feeding on the fruits in the orchards, and in particular because they have continued to damage the fruit surfaces after the fruits have been picked and removed to the packing shed.

Several complaints have been received from growers who have been very concerned on finding a little green caterpillar infesting their stored apples.

In every case examined the species of tortrix responsible proved to be *Cacoecia podana* Scop., which is the most destructive representative of this group of moths.

Observations made in the autumn months of 1936 and 1937 show that these minute caterpillars are brought into the packing sheds along with the fruits, and that many of them remain attached to the apples whilst they are being graded and wrapped.

Several boxes of Cox's Orange Pippin were examined during the first week of December, and many of the fruits were found to be damaged by tortrix caterpillars. A few larvae were still feeding on the fruits, but most of the damage had been caused some time earlier. Some of the fruits were completely rotten, a condition probably brought about by soft brown rots, which frequently follow the initial caterpillar attack. In one box 50 per cent. of the fruits had been damaged, and many of them were worthless.

It is of interest to note that the caterpillars damage the paper in which the apples are wrapped, but it is not known whether they actually devour it or simply remove it in order to get at the fruit. The latter seems to be the more probable.

It is important to mention that the damage referred to above only occurs when the apples are stored in the packing shed and similar places, and never occurs when the fruits are kept in gas storage. The caterpillars have been found also in small numbers

in apple boxes in cold store, and it is possible that some damage may be caused when apples are stored in this manner.

If this type of injury becomes more widespread than it is at present, it may affect not only the producer but also the retailer—since the caterpillars continue to feed until the apples are removed from the boxes.

9. Knotgrass Moth (*Acronycta rumicis* L.).

The caterpillar stage of the Knotgrass Moth is very familar to many growers but few, if any, know the name of the insect or much about its habits.

It is a hairy caterpillar, with humps on its fourth and eleventh segments, and is dark brown-grey with paler markings. It is marked on the back with a series of black patches and reddish spots. There is a row of white spots on each side, and the breathing pores on the sides are also white.

The Knotgrass caterpillar proved to be unusually abundant in August and September in many parts of Kent, and numerous specimens were sent here for determination.

The more usual host plants of the caterpillar seem to be plantain, dock, sorrel, sallow and hawthorn. In addition, moths were bred out from caterpillars feeding upon strawberry, raspberry, blackberry, bramble and hop. It is also partial to apple and several other top and soft fruits.

Although the caterpillar feeds for a considerable period it does not devour very much of the foliage, nor has it been observed feeding on the fruits of its various host plants.

This insect cannot be considered to be of economic importance.

10. Lappet Moth (*Gastropacha quercifolia* L.).

Although the Lappet Moth caterpillar sometimes feeds on apple foliage it cannot be regarded as a pest. In fact it is not a common insect and is usually a welcome addition to the moth collection.

During the latter part of May this caterpillar proved to be abnormally common in an apple orchard at Ditton, near Maidstone.

Instead of the caterpillars feeding on the young foliage (as is usually the case) they confined their feeding to the buds of one year growths of Grenadier apples. This had the effect of causing the buds to become blind, and in the orchard in question the damage was considerable.

The caterpillar is grey-black in colour and is clothed with fine, moderately short hairs. There are two velvety blue bands on the segments adjoining the head. The segment next to the last bears a conspicuous hump, and a fleshy, pad-like appendage is present on the side of the body, just above the legs.

It is most frequently seen by the grower in the winter time, when it hibernates on the shoots, lying fully stretched out, and closely resembling the bark in colour.

11. Case-Bearer Caterpillar (*Eupista nigricella* Steph.).

This Case-Bearer caterpillar usually feeds on the leaves of apple and plum, but an unusual attack was noted at East Malling during the first week of June.

The caterpillars were observed feeding on the fruitlets of sweet and of sour cherries. They pierced the skins and fed on the flesh of the fruits, making little circular tunnels, about an eighth of an inch deep. This type of damage proved to be serious, since it caused the injured fruits to split as they reached maturity.

Similar damage has been noted several times previously but the Case-Bearer caterpillars had not been associated with it.

12. Apple Leaf Skeletonizer (*Anthophila pariana* Clerck).

The caterpillar of the Apple Leaf Skeletonizer is a familiar insect because it skeletonizes the upper surfaces of the leaves of apple trees in a peculiar manner, and thus it is easily "spotted" by the grower.

The first brood may be found in the orchards in April, May and June, and has been locally common in Kent. The second brood proved to be more common than usual in many parts of Kent, and was particularly so in the Maidstone district, and also at East Malling.

When the caterpillars feed on the foliage of established trees they do not cause much harm, but when they attack two- or three-year-old bush trees the damage may be serious.

Some young Cox's at East Malling were badly infested in August. In fact all the leaves of many trees were skeletonized, and later on, when the caterpillars were fully fed, they spun up the leaves with their silken threads into the form of a cone. The chrysalis stage is reached within this cone. The moth hatches out in the autumn.

It proved to be very abundant everywhere in the East Malling district in the autumn and on sunny days some hundreds were noted flying around the flowers of Michaelmas daisies growing in a garden. In cloudy periods they would settle on the flowers and remain until the sun shone again.

Another interesting observation was made in December. While searching for another species of insect in a haystack and stack refuse hundreds of Apple Leaf Skeletonizer moths were found hibernating there. At first they remained quite inactive on the outspread white sheet, but after some time they became active, and eventually flew back to the stack.

It will be interesting to see whether this insect is abnormally common again in 1938.

13. Puss Moth (*Cerura vinula* Sch.).

The caterpillar of the Puss Moth feeds upon poplar, sallow, and other willows during July, August and September, and has not been recorded as feeding on foliage of fruit trees. In one instance at least it has changed its diet from that of poplar.

Some half-grown caterpillars of this moth were received from a farm at Higham, Kent; they fed on apple foliage quite as readily as on poplar, and all reached maturity.

It is possible that the female laid her eggs on apple foliage by accident, or more likely that she was injured in some manner, and the eggs were deposited on the first leaves available.

14. Broom Moth (*Acronycta psi* L.).

Enquiries have been received from growers in the Maidstone district concerning the conspicuous caterpillar of the Broom Moth. This insect which has a large and varied range of host plants is frequently found feeding upon the foliage of apple, plum, gooseberry, strawberry, and blackberry during the months from August to October. It seems to be more common on top and soft fruits than formerly.

The caterpillar is smooth and velvety, rich dark green and spotted with black, and has a series of longitudinal yellow stripes along its back and sides. When fully

fed its colour frequently changes to brown. Doubtless this caterpillar is noticed in the field because of its conspicuous coloration.

It is of no economic importance.

15. Leaf Curling Black Currant Midge (*Dasyneura tetensi* Rüb.).

Very little has been heard of the Leaf Curling Black Currant Midge until recently, since the initial infestation at Matfield some five years ago. One or two minor outbreaks were noted in 1936, but in 1937 it was very prevalent in parts of Kent, Hampshire and Cambridgeshire.

The maggots of the midge cause very characteristic damage to the growing points of the shoots of black currants. The leaves become twisted and malformed by the minute white maggots which live within them.

Very little seems to be known about the habits of this insect at the present time, thus it is of interest to know that Dr. H. F. Barnes, an authority on the group, is studying this insect.

It occurs also in Finland.

16. Large Willow Aphid (*Pterochlorus saligna* Gmel.).

The Large Willow Aphid, as its name implies, normally feeds on willow, but on three or four occasions this very conspicuous brownish-grey species has been found feeding on apple. In each case willows were growing nearby, and it would appear that a few colonies of aphides temporarily migrated to apple from the normal host.

Another interesting record concerning this has been received from a fruit-grower at Cooling, Kent. In this instance some Conference pears were severely infested by a large brownish-grey aphid which, on investigation, proved to be the Large Willow Aphid, and as might be expected willows were growing freely on some marsh land near at hand. It did not cause any harm to the trees.

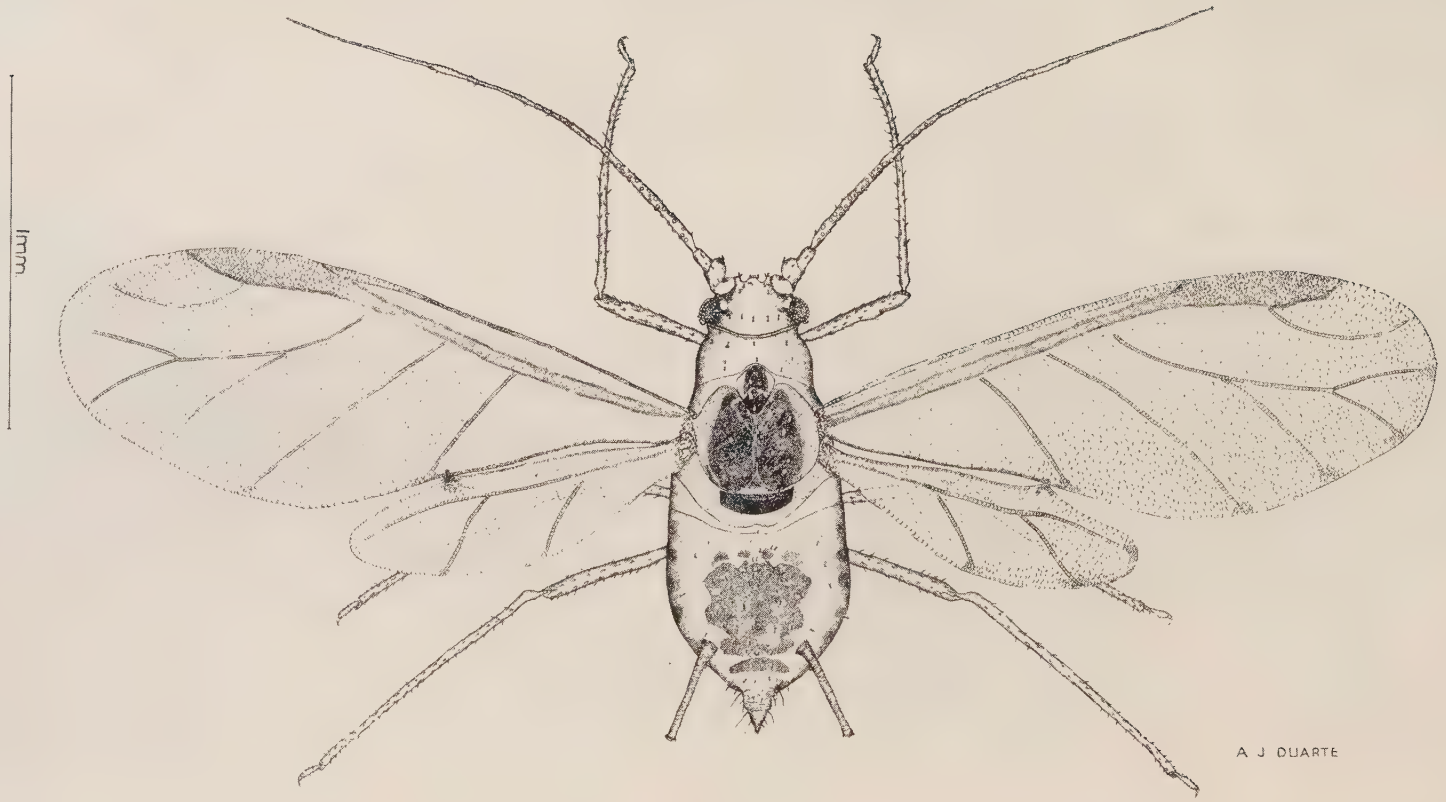
The aphids were still present on the pears in December—an unusually late period of the year for the aphid to be active. The majority of the aphides were winged forms.

Summary.

Brief notes are given of some insects associated with top and soft fruits in 1937.

Amongst those mentioned are the Hop Root Weevil (*Epipolaeus caliginosus* F.); the Codling Moth (*Cydia pomonella* L.); the Fruit Surface-Eating Tortrix (*Cacoecia podana* Scop.); and the Apple Leaf Skeletonizer (*Anthophila pariana* Clerck).

Damage to leaves by the Apple Leaf Skeletonizer (*Anthophila pariana* Clerck).



Strawberry Aphid (*Capitophorus fragariae* Theob.). Alate viviparous ♀.

NOTES ON THE STRAWBERRY APHID (*CAPITOPHORUS FRAGARIAE* Theob.)

By A. M. MASSEE, R. M. GREENSLADE and A. J. DUARTE

Since it has been established that the strawberry aphid *Capitophorus fragariae* Theob. is a vector of Mild Crinkle virus, in addition to that of Yellow-edge, it becomes increasingly important that the life-cycle and ecology of this aphid should be studied in detail under field conditions.

The following notes are not intended to be complete or exhaustive, but since several observations have been made which may be of interest to raisers of clonal plants and healthy runners, it is proposed to publish them in brief.

It is unfortunate that the scientific name of the strawberry aphid has been changed so frequently during recent years. The familiar scientific name, *Capitophorus fragaefolii* Ccl., is not accepted in this country, but has been replaced by the name *Capitophorus fragariae* Theob. This latter name is considered to be the correct one by Mr. F. Laing, of the British Museum, and in a letter dated 8th April, 1937, he states that the change from *fragaefolii* to *fragariae* is necessary.

Notes on Life-cycle.

The apterous viviparous females (wingless females) may be found on the plants all the year round, but the population is much greater during some parts of the year.

The rate of reproduction is very limited during the winter months, but breeding is much more rapid during April and May, and by the middle of June the peak is reached. In July and August the numbers fall off very markedly, and in seasons unsuitable to the aphid, very few individuals survive, though they may be found with difficulty scattered here and there on the plants in the field. During September and October they breed more rapidly and may be found in profusion on the plants.

In the spring and summer months the aphides feed invariably on the under surfaces of the young leaves on the petioles and on the runner stolons, but in the autumn and winter months it is more usual to find them attached to the older leaves, and also tucked away in the crowns of the plants.

In a preliminary investigation carried out in an incubator, kept at a constant temperature of 70° F., it has been found that the apterous viviparous females take from eight to twelve days to reach maturity, the average period being nine days.

During this time the aphid moults three times, the time between each moult being three days. Under controlled conditions this figure appears to be very constant.

In addition some preliminary information has been obtained upon the number of young produced by a single wingless viviparous female. Under natural conditions the aphid mortality appears to be very high, thus it is extremely difficult to obtain an accurate figure of the number of young produced.

It is fully realized that the following figures may not show what happens under natural conditions, but they are given as a matter of interest. One aphid produced five living young in two days and then perished ; a second, six in four days ; a third, seven in seven days ; a fourth, sixteen in seven days ; a fifth, fourteen in nine days, and the

sixth produced thirty-one aphides in eighteen days and then died. Further observations show that the life of the wingless female ranges over a period of from two to four weeks, three weeks being the more usual time.

Migration Periods.

The fact that the aphid migrates at certain periods of the year is a very important one, because the danger of transmitting one or more of the strawberry virus diseases from one field to another becomes a very real problem. In this connection it is of interest to note that the spread of Yellow-edge on certain plots at the Research Station coincided exactly with the spring migration of 1937.

The spring migration period in the Maidstone district of Kent in 1937 was very short, lasting precisely one week. Aphides with wing buds were noted on the plants during the latter part of May, but the fully developed winged forms (capable of flying) were not noted prior to 28th May. They were very plentiful from that date until 3rd June inclusive. Certain strawberry plots at East Malling which were being kept under constant observation were noted as being infested during this spring migratory period—previously these plants had not been infested by aphis.

It should be observed that the whole aphid population does not become winged during the spring migratory period, but that a large number of viviparous apterous forms continue to breed on the plants throughout the summer months.

For several years now it has been observed that there is a second period in which winged forms are produced, and in 1937 these winged forms were first noted in the field on the 22nd of September. This second winged period differs considerably from that in the spring. For example, in 1937 it extended over a long period, from the latter part of September until the end of November. Although winged forms were present for more than nine weeks there is no evidence to show that any form of migration takes place ; in fact daily observations confirmed the view that the aphides did not even attempt to fly from one plant to the next in the same row, and they certainly did not migrate to other strawberry fields. Greased boards placed at intervals in one field (under observation) did not catch any winged forms in the autumn, whereas during the spring migration they were plentiful.

It is true that the weather conditions during the autumn were not at all favourable to the insects, therefore it must be borne in mind that if conditions had been more suitable, a general migration might have taken place, similar to that recorded at the end of May.

It must not be assumed that the aphides migrate only by means of their winged forms. Observations have shown that the wingless forms move about freely from plant to plant at most seasons of the year.

Apterous males occur on the plants during December, and the sexual forms may be found each year during the latter part of December and in January.

The Egg Stage.

The eggs of *Capitophorus fragariae* Theob. are very difficult to find in the field, and since similar eggs of other species of aphides are also present on the plants at the same time of the year, some confusion must of necessity arise. The egg is black and shiny, and is generally found on the under-surfaces of leaves and in amongst the hairs of the petioles.

The average size of twelve eggs deposited on strawberry leaves in the laboratory was $0{\cdot}68 \times 0{\cdot}32$ mm.

Alternative Host Plants.

There is no doubt that the strawberry aphid can exist all the year round on the cultivated strawberry, and thus the question of alternative host plants does not appear to be of primary importance. Nevertheless, it must not be assumed that the strawberry aphid does not feed on other plants. A continuous survey has been made on various wild plants from May until October inclusive, during 1937. In the course of this survey colonies of the strawberry aphid were found on Silver-weed (*Potentilla anserina* L.).

A strong colony was found on Silver-weed growing at the edge of a cut-down wood at East Malling, the distance from the nearest cultivated strawberries being approximately half a mile. Large numbers of aphides were also found on Silver-weed growing adjacent to a pond, on a by-road near the village of East Malling. Further examples were found on Silver-weed growing along the main road at Hildenborough, Kent. In this instance they occurred on some plants which were also infested with another species of Capitophorus. Aphides from these three sources were collected and transferred to strawberries growing in pots ; strong colonies were quickly established, and winged forms developed in the autumn, towards the end of September.

Systematic inoculations were made each week from May to September inclusive to determine whether colonies of the strawberry aphid could be established on the wild strawberry (*Fragaria vesca* L.) growing under natural conditions. The aphides were placed on plants growing along with the usual woodland flora, and also on plants growing at the edge of a wood, under more open conditions. As already stated the inoculations were made weekly throughout the summer, but it was found to be impossible to establish them on the plants. They either perished or wandered away.

Hodson* in a recent paper states, " In the field the writer has only found the aphis on cultivated strawberry, but has induced it to colonize freely upon wild strawberry, potentilla and cultivated rose."

The strawberry aphid has never been found by the authors on wild strawberry plants growing in woods, under natural conditions. Therefore, the following facts are worthy of record.

In June, 1937, well-established colonies of strawberry aphides were discovered on some wild strawberries growing in pots. The pots were plunged in the open ground, adjacent to a range of greenhouses at the Research Station. Doubtless the plants became infested during the spring migration period at the end of May. It is difficult to explain why these plants should be subject to attack, but it may be partly due to the fact that they had been removed from their normal environment to an artificial one, and also that the soil was very different from that found in the woodland. It should be stated that the plants were growing very vigorously, and were very unlike the familiar wild strawberry.

At the end of July, 1937, some twenty plants of Silver-weed were growing wild in a lane near Ryarsh Village, on the North Downs, which were inoculated with apterous viviparous females of the strawberry aphid. The aphides established themselves on the plants, and were still present at the end of the year, although the leaves had died down completely.

Thus it will be seen that the strawberry aphid can live on plants other than the cultivated strawberry, under certain conditions, therefore the question of alternative hosts cannot be ruled out entirely.

* Hodson, W. E. H., On the Synonymy and Biology of the Strawberry Aphis, *Capitophorus fragariae* Theo. (1912). Bull. Ent. Soc., 1937, **28,** 409-16, 2 Pl.

Conclusions.

From the available knowledge of the life-cycle of the strawberry aphid, certain phases seem to be of primary importance. For example, from the point of view of aphis control, it will be essential to begin operations in the spring before the winged forms appear at the end of May. In 1937 the winged forms were present for a very short period—namely one week. It is possible that the date of appearance of winged forms may vary from year to year. This will have to be checked over a period of years. Again in 1937 the winged forms which appeared in the autumn did not migrate at all, but in a more favourable season it is quite possible that a partial migration may take place.

The fact that the apterous viviparous females migrate from one plant to another is somewhat disturbing, and may account to a large degree for the spread of the virus diseases under field conditions.

In future it will be imperative to study the aphid in the field in some detail, in order that control measures can be put in operation before the winged forms appear and cause a general spread of the insect in the neighbourhood.

Summary.

1. Notes on the life-cycle of the strawberry aphid (*Capitophorus fragariae* Theob.) are given.

2. It has been found that the aphid can live all the year round on the strawberry, but under certain conditions it will breed quite readily on Silver-weed.

3. Two winged periods were noted in the Maidstone district of Kent in 1937, one in the latter part of May, and the second at the end of September.

4. The apterous viviparous females migrate readily in addition to the winged forms.

STUDIES OF IMPREGNATED TREE BANDING MATERIALS

IV. APPLE BLOSSOM WEEVIL AND CODLING MOTH EXPERIMENTS IN 1937

By A. M. MASSEE, R. M. GREENSLADE and A. J. DUARTE

Previous Work at East Malling.

A brief survey of previous work with trapbands was included in the account of experiments in 1936 (Massee, Greenslade and Brair, 1937). The experiments in 1936 showed that the solvent in which beta-naphthol was dissolved had little effect on the number of insects caught but that the amount of beta-naphthol present in the band affected the number of weevils caught. The 1937 work was therefore designed to show the effect of the weight of the chemical present in the band. The weight of substance deposited on a given length of band is referred to, for convenience, as the concentration of the treatment.

Materials Used.

Corrugated cardboard bands 2 inches wide were used for all treatments, and two series of 4 inch bands were included for comparison. The treatments chosen were two "Seekay" waxes which had previously been attractive to Codling larvae, and tetrachlorbenzene which attracted Apple Blossom Weevils. These were compared with untreated bands and with commercially obtainable beta-naphthol bands. The treated bands contained a known weight of substance per 100 feet of band as shown below:

Seekay wax AX.111	2 in. bands	20 oz./100 ft.
,,	2 in. ,,	15 oz./100 ft.
,,	2 in. ,,	10 oz./100 ft.
,,	4 in. ,,	40 oz./100 ft.
Seekay wax A.123	2 in. ,,	20 oz./100 ft.
,,	2 in. ,,	15 oz./100 ft.
Tetrachlorbenzene	2 in. ,,	10 oz./100 ft.
,,	2 in. ,,	5 oz./100 ft.
,,	2 in. ,,	2·5 oz./100 ft.
Beta-naphthol	2 in. ,,	
Untreated	2 in. ,,	
,,	4 in. ,,	

The bands were applied on 25th May to a block of 693 trees of the variety Lord Derby, 20 years old. Eighty of these trees had been top grafted with another variety and had not yet come into bearing. As they were equally spaced through the block they were banded with untreated bands to find out if many of the Codling larvae would wander to these trees before hibernating. These bands were found to catch about one-quarter of the number of insects caught by similar bands on fruiting trees.

Damage by Poultry.

In this and all previous experiments bush trees were used and the bands were within 2 feet of the ground. This proved to be a disadvantage in this case as fowls were turned into the orchard and began to destroy the bands in August to get the Codling larvae. Two hundred and twenty-five bands were destroyed or too damaged to be included in the trial. The damage became so serious that the bands had to be removed somewhat earlier than they would have been in the ordinary way. However, this probably made little difference to the result as the fruit had been picked two months before and on the day after picking all the dropped fruit had been gathered up and destroyed. The following table shows the amount of bird damage suffered by the different treatments.

Table I.

Bird Damage.

Treatment.	No. of bands.	Per cent. of total number of bands.		
		Destroyed.	Badly damaged.	Slightly damaged.
Untreated 2 in.	40	20·0	17·5	20·0
do. 4 in.	27	3·7	18·5	29·6
Beta-naphthol	55	5·4	1·8	12·7
AX.111 20 oz.	55	29·1	14·5	21·8
do. 15 oz.	54	25·9	11·1	31·5
do. 10 oz.	55	29·1	12·7	29·1
do. 40 oz., 4 in.	56	5·4	10·7	37·5
A.123 20 oz.	55	18·2	12·7	30·9
do. 15 oz.	53	26·4	9·4	28·3
Tetrachlorbenzene 10 oz. ..	53	33·9	20·7	16·9
do. 5 oz. ..	54	33·3	22·2	33·3
do. 2·5 oz. ..	52	46·1	9·6	23·0
Untreated on regrafted trees ..	80	8·8	13·8	18·7

This table shows that beta-naphthol is the only treatment which prevents hens from damaging the bands. It is obvious that a badly damaged 2 inch band may fall off the tree while a 4 inch band just as badly damaged will not, but it is unlikely that wild birds would do so much harm, therefore the differences shown in Table I between wide and narrow bands need not be considered. The slight differences between treatments other than beta-naphthol are probably not significant as all bands were torn off indiscriminately in the part of the plot near the hen houses.

Examination of the Bands.

The bands were removed from the trees between 4th and 8th October, 1937, and all weevils and Codling larvae were counted. In Table II the results of these counts are given as the average catch per band. The numbers found on the tree under the band are the numbers of weevils and Codling larvae left behind when the bands are removed. Some of these Codling larvae bore partly into the bark and are destroyed by birds, but many seek fresh hiding places and so do the weevils. In some cases the number left behind is quite a high proportion of the total catch. Altogether 7,324 weevils and 2,741 Codling larvae were counted on 468 trees. A number of Codling pupa cases were found in the bands, protruding from the cocoons, which showed that there was a partial second brood in 1937.

Most of the 2 inch bands separated on removal from the tree and some weevils were lost. These bands are narrow and the corrugations are open at the top so that rain enters and softens the glue holding the corrugated paper to the outside plain paper. A waterproof paper covering to keep rain out of the corrugations is undoubtedly a great advantage. This does not apply to the beta-naphthol bands, as this treatment is dissolved in lubricating oil which protects the band from wet.

TABLE II.

Treatment.	No. of trees.	Average per tree.			
		Weevil.		Codling larvae.	
		In band.	On tree.	In band.	On tree.
Untreated 2 in.	30	16·5	2·4	5·0	1·2
do. 4 in.	26	9·5	2·8	8·6	1·8
Beta-naphthol	55	0·2	1·1	4·4	0·7
AX.111 20 oz.	33	11·5	1·1	4·7	0·9
do. 15 oz.	35	4·9	2·7	4·9	1·2
do. 10 oz.	34	6·9	2·3	7·7	1·4
do. 4 in., 40 oz.	46	35·3	2·6	7·8	1·2
A.123 20 oz.	37	14·0	3·2	5·5	0·8
do. 15 oz.	36	8·5	2·1	6·0	0·9
Tetrachlorbenzene 10 oz. ..	23	30·3	4·0	4·0	1·2
do. 5 oz. ..	24	20·8	5·3	2·6	0·6
do. 2·5 oz. ..	24	29·9	4·6	3·1	0·4
Untreated on regrafted trees ..	63	5·0	1·3	1·4	0·3

RESULTS WITH APPLE BLOSSOM WEEVIL.

Effect of concentration of treatment : The higher concentrations of the two Seekay waxes were the more attractive, that is 20 oz. per 100 feet of band. There was no difference between 10 oz. and 2·5 oz. of tetrachlorbenzene but 5 oz. was significantly less attractive. This needs verification in further experiments.

Comparison of treatments : The following list gives the best concentration of each treatment in order of attractiveness. Only two differ significantly from the untreated controls.

Beta-naphthol	0·2 per band
AX.111 20 oz.	11·5 ,,
A.123 20 oz.	14·0 ,,
Untreated	16·5 ,,
Tetrachlorbenzene	30·3 ,,

It will be seen that tetrachlorbenzene definitely attracts Apple Blossom Weevils and beta-naphthol repels them.

Comparison of wide and narrow bands : 4 inch bands untreated and treated with AX.111 at 40 oz. per 100 feet were included in the trial. The treated 4 inch band caught more than three times the number of weevils found in the 2 inch 20 oz./100 feet band with which it is comparable. The 4 inch untreated band caught less than the corresponding narrow band. There seems to be no obvious explanation for this.

Results with Codling Larvae.

Effect of concentration of treatment: The lowest concentration of AX.111 (10 oz. per 100 feet) was significantly more attractive than either 15 or 20 oz. The various concentrations of the other treatments did not differ significantly.

Comparison of treatments: Only one treatment was more attractive than an untreated band. This was AX.111. The best concentration of each treatment is compared below with the untreated bands.

Tetrachlorbenzene 10 oz.	4·0 per band	
Beta-naphthol	4·4	,,
Untreated	5·0	,,
A.123 15 oz.	6·0	,,
AX.111 10 oz.	7·7	,,

The results within each bracket do not differ significantly.

Comparison of wide and narrow bands: It will be seen from Table II that both the treated and untreated 4 inch bands caught nearly twice as many larvae as the 2 inch ones.

Estimation of Codling Population in the Orchard: Thirty-four trees distributed through the block were marked at the beginning of the season, and all fallen fruit was examined at intervals of a few days up to picking time. The crop picked from these trees was also examined. The so-called June drop was not included in this examination as no Codling larvae were present at that time. By counting these larvae the proportion of infested fruits in the orchard was determined. Assuming that each infested fruit represents one Codling larva an estimate could be made of the population in the orchard. The total number of apples examined was 4,035 which was a light crop for thirty-four trees. Of these, 682 were infested. The average crop per tree was therefore 118·7 and the average infested fruits per tree was 10·1. Table III gives the average number of larvae per band for each treatment, expressed as a percentage of 20, the estimated population per tree. This may also be regarded as the percentage of the total population which would have been caught had the whole block of trees been banded with the same treatment.

Table III.

Treatment.	Average larvae in bands.	Percentage caught.
Untreated 2 in.	5·0	24·7
do. 4 in.	8·6	42·8
Beta-naphthol	4·4	22·1
AX.111 20 oz.	4·7	23·3
do. 15 oz.	4·9	24·4
do. 10 oz.	7·7	38·6
do. 4 in. 40 oz.	7·8	39·0
A.123 20 oz.	5·5	27·6
do. 15 oz.	6·0	30·2
Tetrachlorbenzene 10 oz.	4·0	20·2
do. 5 oz.	2·6	12·9
do. 2·5 oz.	3·1	15·4

Approximately 17 per cent. of the total apples available to Codling were infested, and of the picked crop 12·5 per cent. was infested.

The bands treated with AX.111 at 10 oz./100 feet caught nearly 40 per cent. of the population on those trees. It would be interesting to see whether a 4 inch band treated with the same amount would catch 60 per cent. or more.

Conclusions.

It is difficult to compare these results with those of previous years as the exact amount of substance present in the bands was not then known, or was measured in a less satisfactory way. The relative attractiveness of the various treatments has varied from year to year. This may be due to variations in the " concentration " of the treatment, but it is not clear why the untreated controls were better than anything else in 1936. A possible explanation put forward at the time was that bird damage had made the 1934 and 1935 counts unreliable (Massee, Greenslade and Brair, 1937). This is now ruled out as damaged bands were not included in the counts except those which are recorded as slightly damaged. (This means bands which had been pecked once or twice but which had not been torn open anywhere.) The high figures for the controls in 1936 are still not explained.

This year's results show that the amount of chemical present in the band may affect the number of weevils or Codling larvae caught, and suggests trying a more extended range of " concentrations ".

It seems on the whole that 4 inch bands catch more weevils and Codling larvae than 2 inch ones. The difference may not be so great as it appears in the case of weevils as the 2 inch bands separate on removal and a few weevils are inevitably lost. This, however, does not apply to the Codling larvae as very few fall and such as do fall are easily seen. Four inch bands should be tried at more " concentrations " as it seems that with suitable treatment they might catch a very high proportion of the Codling population. In particular a 4 inch band treated with 10 oz. or less of AX.111 per 100 feet would be interesting.

It has still not been possible to find a treatment which is equally attractive to weevils and to Codling larvae.

The results obtained from the commercial beta-naphthol bands and from untreated bands were not significantly different in this year's trial.

Acknowledgments.

This investigation has been carried out in collaboration with Imperial Chemical Industries, Ltd., both the chemically treated and untreated bands being supplied by them, and we wish gratefully to acknowledge their assistance.

The writers are once again indebted to Mr. G. H. L. Dicker, B.Sc., for his assistance and interest in the investigation.

Summary.

An account is given of experiments with trapbands against Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.) and Codling Moth (*Cydia pomonella* L.).

Corrugated cardboard bands were used, containing various weights of four different chemical treatments, two " Seekay " waxes, tetrachlorbenzene and beta-naphthol.

A " Seekay " wax treatment attracted Codling larvae, tetrachlorbenzene attracted weevils, and beta-naphthol repelled weevils. Other treatments did not differ significantly from untreated bands.

The number of insects caught was affected by variations in the weight of chemicals in the band and by the width of the band.

The degree of Codling infestation in the orchard was calculated and from this it was found that some treatments caught as much as 40 per cent. of the population of the trees to which they were applied.

Reference.

Massee, A. M., Greenslade, R. M. and Brair, J. H. "Studies of Impregnation of Tree Banding Materials. III. Apple Blossom Weevil and Codling Moth Experiments in 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (May, 1937), 232-9.

INSECTICIDES AND FUNGICIDES

SPRAY RESIDUE INVESTIGATIONS

II. THE INFLUENCE OF SPRAY SUPPLEMENTS ON THE RETENTION OF LEAD ARSENATE ON APPLES

By H. SHAW and W. STEER

It has recently been shown (5, 6) that a late June arsenical spray is desirable for the control of Codling Moth on apples and (4) that lead arsenate alone cannot be applied much later than the end of June, except to very late varieties of apple, without exceeding at picking time the tolerated residue of 0·01 gr. As_2O_3 per lb.

It has been generally believed that the addition of lime-sulphur increases the " sticking " power of lead arsenate, that a wetting agent gives rise to a more even but less heavy deposit, and that the inclusion of oil increases both the initial deposit and the persistence of the residue. The present investigation, carried out in 1937, was designed to obtain quantitative data in confirmation or otherwise of these impressions.

The materials used in the trial were :

A. *Lead arsenate paste* containing 15-16% arsenic pentoxide, at 0·4%,

L.S. *Lime-sulphur solution*, sp. gr. 1·3, polysulphide sulphur (by weight) approx. 20%, at 0·75%,

Leth. *" Lethalate " Standard Wetting Preparation*, at 0·05% and

Oil. *Shell oil* 24413 emulsified with sulphite-lye (2), at 1% oil.

The combinations selected for investigation were :

1. **A.LS.**
2. **A.LS.Leth.**
3. **A.**
4. **A.Leth.**
5. **A.Oil.**

The five treatments were arranged at random in a row of bush apple trees of the variety Cox's Orange Pippin so that each spray was applied to two trees, one in each of two blocks.

The trees were sprayed on 30th June in as uniform a manner as possible, using a moderately fine spray and taking care to use similar amounts of each wash.

After the sprays had dried it was observed that

(*a*) lead arsenate alone gave a heavy but uneven and patchy deposit,

(*b*) the addition of lime-sulphur gave rise to a more even yet almost as heavy deposit,

(*c*) the addition of the wetter resulted in a more even but lighter deposit. On the fruits it apparently caused most of the spray to run off the upper surface leaving only a very thin deposit, and to accumulate as a heavier deposit on the undersides, and

(*d*) the lead arsenate-oil mixture gave the most unevenly distributed deposit, consisting of heavy patches concentrated particularly where leaves or leaves and fruit were in contact.

Leaf scorch and leaf fall during the fortnight following spraying were most pronounced wherever lime-sulphur or oil had been included but none of the damage was severe. None of the sprays influenced the size of the fruit at any stage.

Samples of leaves and fruits were collected for chemical examination approximately two weeks, five weeks and eight weeks after spraying. From each tree two random samples were taken each of one hundred leaves and as representative as possible of all sections of the tree. In the later samplings leaves that had obviously been produced after the application of the sprays were avoided. Similarly two samples of fruits per tree were picked at random. Each weighed about a pound and contained 12-15, 8-9 or 6-7 fruits according to the date of picking.

Owing to unforeseen circumstances it was not possible to begin the analyses until some weeks after the last picking had been completed and a somewhat exceptional treatment of the samples was thus made necessary. The mid-July fruit samples were weighed into large tins, sealed and placed in cool storage (12° C.) where they remained for six months. The two samples of fruit picked in August were kept in punnets in a cool room (average temperature 10-15° C.) for three months. Of the leaf samples those collected in mid-July and half those in late-August were digested immediately after weighing whereas the early-August and the other half of the late-August samples were air-dried and stored.

The fruit samples were dealt with in the usual manner (1) with minor modifications of procedure. In the case of the fruit from cool storage the emptied tins were quickly rinsed with 20 ml. of 4% hydrochloric acid followed by a like quantity of distilled water. The washings were added to the sample prior to digestion. The final dilutions and evaporations of the leaf samples were carried out in beakers and those of the fruit samples in the Kjeldahl flasks. Excessive bumping at this stage, caused by the very heavy sediment of lead salts and silica, resulted in the loss of a few samples. Duplicate estimations of the arsenic were made by the Gutzeit method and a mean value per sample thus obtained. The means per tree were then calculated from each pair of samples and an analysis of variance was carried out on these means. The results are summarized in Tables I and II.

TABLE I.

FRUITS: PARTS As_2O_3 PER MILLION.

Date of sample	A.LS.Leth.	A.LS.	A.	A.Leth.	A.Oil.	
						General Mean = 1·7
15th July	2·185	2·16	2·51	2·375	3·20	Standard Error = 0·16
5th August	1·205	1·41	1·445	1·37	2·805	Significant Difference
23rd August	0·805	0·94	0·77	0·675	1·575	(P=0·05) = 0·49
Mean of three dates	1·40	1·50	1·58	1·47	2·53	Standard Error = 0·09 Significant Difference = 0·28

The arsenical deposit was much heavier on fruits sprayed with lead arsenate-oil than on any of the others. This superiority was maintained throughout the period covered by the chemical analyses. Between any of the remaining treatments no significant difference could be detected. The loss of arsenic from the fruits during the first period (15th July to 5th August) was least in the lead arsenate-oil treatment and during the second period (5th August to 23rd August) least wherever lime-sulphur had been included.

On 1st October, after the crop was picked, visual inspection showed the white residue to be most conspicuous on the fruit from the lead arsenate-oil trees and less so, but still noticeable, wherever lime-sulphur had been used. Scarcely any trace remained on fruits that had been sprayed with lead arsenate, with or without wetter. The effect of the oil on the retention of the lead arsenate residue was even more marked on the leaves.

By 23rd August even the heaviest deposit (lead arsenate-oil) was little above the tolerated maximum and undoubtedly would be below this when the fruit was picked in late September. Even so, the visible deposit on the picked fruit was just too conspicuous to be ignored.

Shortly after this work was completed, Pescott and Miller (3) showed that arsenical residue is significantly less where a spreader is included with lead arsenate, and Weber, McLean, Driggers and O'Neill (7) found that the inclusion of oil increases both deposition and retention of the arsenate.

TABLE II.

LEAVES: PARTS As_2O_3 PER MILLION.

Date of sample	A.LS.Leth.	A.LS.	A.	A.Leth.	A.Oil.	
15th July	134	131	129	148	247	General Mean = 161
4th August	145	95	120	220	285	Standard Error = 46
24th August	167	83	112	168	233	Significant Difference (P=0·05) = 140
Mean of three dates	159	103	121	179	254	Standard Error = 27 Significant Difference = 81

As far as can be ascertained from the data in Table II, the amount of arsenic deposited or retained was not influenced by the addition of lime-sulphur, of Lethalate or of lime-sulphur and Lethalate, but was increased by the addition of oil. These results are, however, inconclusive and very irregular. Pescott and Miller (*loc. cit.*) report a similar lack of uniformity in analyses of leaf samples.

The method of sampling was clearly inadequate to overcome the large variation in arsenical deposit on leaves and so failed to reveal any but very large differences. Leaves vary much more than fruits in the amount of arsenical deposit retained probably because they are more variable in size, position and spacing. Further variability may arise from the inclusion in the sample, despite the effort made to avoid them, of a few new leaves produced after the sprays were applied.

SUMMARY.

In an investigation of the effect of spray supplements on the deposition and retention of lead arsenate, the amount of arsenical residue retained by the fruits was increased by a refined petroleum oil but not significantly affected by lime-sulphur, by Lethalate or by lime-sulphur and Lethalate.

On leaves the effect was similar but less clearly defined because of inadequate sampling.

ACKNOWLEDGMENT.

The authors are indebted to their colleague Mr. T. N. Hoblyn for help and advice in the statistical examination of their data.

References.

(1) Association of Official Agricultural Chemists, Official and Tentative Methods of Analysis. Fourth Edition, Washington, D.C., 1936, 371-2.

(2) Kearns, H. G. H., Marsh, R. W. and Pearce, T. J. P. "Experiments with Combined Insecticide-Fungicide Sprays for Apples." Long Ashton Res. Sta. Ann. Rep., 1932, 66-85.

(3) Pescott, R. T. M. and Miller, L. W. "Codling Moth and Williams Pears." J. Dept. Agric., Victoria, 1937, **35,** 501-12.

(4) Shaw, H. "Spray Residue Investigations. I. Determinations of Arsenic on Pears and Apples and of Copper on Loganberries." E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 240-5.

(5) Steer, W. "Observations on Codlin Moth in 1935." E. Malling Res. Sta. Ann. Rep. for 1935 (1936), 186-90.

(6) ——— "Observations on Codling Moth in 1936." E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 250-8.

(7) Weber, A. L., McLean, H. C., Driggers, B. F. and O'Neill, W. J. "Influence of Different Materials on Coverage and Adhesiveness of Sprays and Their Effect on Residue Removal from Apples." New Jersey Agric. Exp. Sta. Bull. 627, 1937.

EXPERIMENTS IN THE CONTROL OF PLUM SAWFLY ON CZAR PLUMS

By W. STEER and A. A. G. HASSAN*

In many districts the Plum Sawfly (*Hoplocampa flava* L.) is a serious pest and causes big losses to plantations of Czar plums and damsons.

The first experiments to yield satisfactory results on the control of this pest were carried out by Petherbridge and Thomas (3) who found that it could be adequately controlled by spraying twice with a Derris wash, once at the beginning of " cot-split " and again a week later. Subsequently Kearns, Marsh and Martin (2) and Petherbridge and Thomas (4) confirmed these results in experiments which suggested that the toxicity of a Derris wash could be enhanced by the addition of a petroleum emulsion, which also improves its acaricidal properties.

Spraying trials were carried out at East Malling in 1936 and 1937 largely :

(i) to determine the effect of time of application of a Derris wash, i.e. to compare the early and late applications that Petherbridge and Thomas (3) recommended,

(ii) to ascertain whether two sprayings give substantially better results than a single one,

(iii) to compare various wetting agents as spray auxiliaries, and

(iv) to compare Derris with other insecticides.

1936 Trial.

This trial was carried out in a plantation of medium-sized Czar plum trees belonging to Mr. R. Thompson, of Addington, Kent, and consisting of two long rows and several part rows.

The two long rows were divided into six plots of twelve trees each. Four plots were sprayed with Derris and two with nicotine on 14th May. Two of the Derris plots were to have been sprayed again a week later, but unsuitable weather prevented spraying.

Nicotine was tested partly to ascertain whether Plum Sawfly is amenable to the treatment that gives such good results against Apple Sawfly (*Hoplocampa testudinea* Klug.) and partly because promising results had been obtained by Sprengel (5) and by Petherbridge and Thomas (3) with sprays containing nicotine sulphate.

The nature of the spray materials and the concentrations at which they were used were :

Derris : A proprietary brand of ground Derris root. Ether extract 10·4%, crude rotenone 2·73%, crystalline rotenone 2·14%. Used at 2 lb. per 100 gallons (0·2%).

Nicotine : 95-8% purity. Used at 8 oz. per 100 gallons (0·05%).

* Of the Egyptian Ministry of Agriculture, and attached to the Insecticides and Fungicides Section of East Malling Research Station from October, 1936 to August, 1937.

Wetter : " Lethalate " Standard Wetting preparation. 75% commercial sodium lauryl sulphate, 20% alkali salts of di-isopropyl naphthalene sulphonic acids and 5% natural gum. Used at 8 oz. per 100 gallons (0·05%) with each of the above.

The following biological data were recorded :

12th May. A few blossoms still left. Cots splitting ; a few completely split. Two sawflies caught.

14th May. Most of the petals fallen. Very many cots split and many of the fruitlets quite free of the cot. No larvae found. Sprays applied.

30th May. Infestation well advanced. Derris sprayed plots obviously freer than either nicotine-sprayed or control plots.

On 4th and 6th June the infestation was assessed by counting the damaged fruitlets in samples of 250 on each of two branches chosen at random on each tree. The attack on unsprayed trees at each end of the two sprayed rows and in the part rows on either side was estimated in a similar manner. The result is shown in Table I.

TABLE I.

CONTROL OF PLUM SAWFLY AT ADDINGTON, 1936.

Spray Treatment.	Total Number of fruitlets examined.	% infested.
Derris 0·2%	8,000	4·9
Nicotine 0·05%	4,000	27·2
Unsprayed Controls	6,000	22·4

Derris gave good results (and of the same order as those obtained by Petherbridge and Thomas) but nicotine evidently had no effect. The failure of the nicotine can presumably be attributed to the difficulty of penetrating the cots, which adhere closely to the sides of the young fruitlets and which contain the eggs. On the other hand, the deposit left by Derris is doubtless toxic to the young larvae that subsequently come into contact with it.

The set of plums was good and resulted in a very heavy crop that showed little or no reduction of yield caused by sawfly. An attempt to weigh the crop from the various plots was, therefore, abandoned.

1937 TRIALS.

Spraying trials were carried out on the farms of Mr. R. Thompson at Addington, and Mr. S. May at West Farleigh, to gain information on the optimum time to spray, the number of applications necessary, and the comparative values of various wetters. In both of these the infestation proved too low to warrant extensive counts. Successful trials were, however, carried out at East Malling and at the farm of Mr. H. Foreman of Chelsfield, Kent.

Chelsfield. This experiment was conducted on six rows of large, closely planted Czar plum trees—about 80 trees in all. Two rows on one side of the plantation were sprayed with Derris and soap on 14th May, two rows on the other side on 22nd May, and the remaining (centre) two rows were sprayed on both dates. Blocks of six trees each were left unsprayed in each pair of rows. (See Fig. 1.)

The Derris was similar to that used in the 1936 trial and was again diluted to 0·2%. The soap was prepared by dissolving 3 oz. of caustic soda in 50 gallons of water and then adding a pint of Commercial Brown Oleine. On each occasion the spraying was followed by rain.

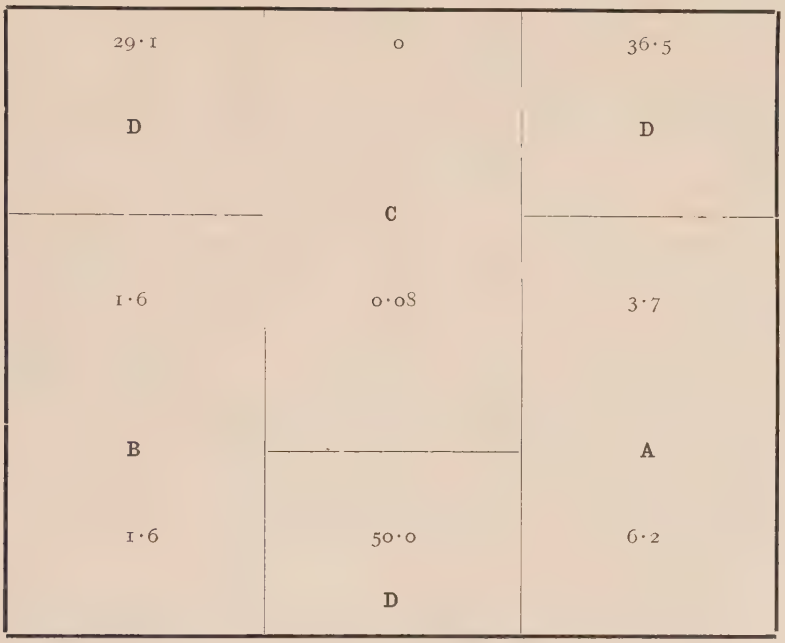


FIG. 1.

Showing mean per cent. damaged fruitlets on various parts of the plantation.

A = early application (of Derris and Soap), 14th May.
B = later application (of Derris and Soap), 22nd May.
C = double application (of Derris and Soap), 14th and 22nd May.
D = unsprayed controls.

The following biological data were recorded:

29th April. Trees just past full bloom. Very few petals fallen and a few blossoms still to open. Two sawflies found.

14th May. Much blossom still left and not more than 80% of the petals fallen. A great many cots beginning to split. No larvae or sawflies found. First spray applied.

22nd May. No larvae found. Second spray applied.

29th May. Infestation well advanced on unsprayed trees. Sprayed trees apparently clean.

On 9th June the infestation was assessed by means of two random samples (each of 200 fruitlets) per tree, with the result shown in Table II.

The later spraying appears to have given a somewhat better result than the earlier one, but the simple layout of the trial, and the observed fact that sawfly infestation was heavier towards the southern corner, together preclude the possibility of confirming this by any legitimate method of statistical analysis.

Similarly, the double spraying was apparently superior to either of the single sprayings. It is clear, however, that a single spraying on either of the dates (14th or 22nd May) gave satisfactory results.

Fig. 1 shows the layout of the trial and the mean percentage infestation recorded on plots of six trees each in various parts of the plantation.

TABLE II.

CONTROL OF PLUM SAWFLY AT CHELSFIELD, 1937.

Spray Treatment.	Total Number of fruitlets examined.	Mean % infested.
A. Derris and Soap, 14th May	2,400	5·0
B. Derris and Soap, 22nd May	2,400	1·6
C. Derris and Soap, 14th and 22nd May	2,400	0·04
D. Unsprayed controls	3,600	35·4

East Malling. Two small scale trials were carried out on a row of Czar plum trees. Sixteen trees were divided into four blocks of four trees each and the following treatments were given to individual trees chosen at random in each block :

A. Lead arsenate paste .. .. .. 0·4%
B. Thiodiphenylamine .. .. .. 0·1%
C. Derris .. .. 0·2%
D. Controls, unsprayed.

Derris was also applied at a concentration of 0·1% to four trees in the same row to ascertain whether a lower concentration than that usually employed is likely to give satisfactory results.

The thiodiphenylamine was undergoing laboratory and field tests against various types of insect as a possible, and less poisonous, substitute for lead arsenate and was therefore included in these trials. It was used in the form of a preparation containing 93% of thiodiphenylamine.

Lead arsenate was used, partly because of promising results given by washes containing lead arsenate in some of the trials carried out by Sprengel (5), Petherbridge and Thomas (3) and Tonini (6), but chiefly as a standard of comparison for the thiodiphenylamine.

The Derris and the thiodiphenylamine were each used in conjunction with a soap solution prepared in the manner described on page 225. The lead arsenate was used without added wetter.

The following biological data were recorded :

21st-23rd April. Full bloom. Much blossom still to open. Six sawflies caught in half an hour.

3rd May. About 30% of the petals fallen. Sawflies abundant.

8th May. 70-5% of the petals fallen. A few cots beginning to split.

14th May. The first newly hatched larva found. This had hatched (in a muslin sleeve) from one of several eggs that were laid on 6th May.

17th May. Sprays applied.

25th May. Many larval entries apparent on unsprayed trees.

On 4th and 5th June the infestation was assessed by counting the damaged fruitlets in random samples of 200 fruitlets. Four such samples were counted on each tree, making a total of 3,200 fruitlets to each treatment. The result is shown in Table III.

TABLE III.

CONTROL OF PLUM SAWFLY AT EAST MALLING, 1937.

Spray treatment.	Mean % infested fruitlets.	*S.E.*	*Significant difference* (P = 0·05)
Derris 0·2% and Soap	4·6	3·0	8·6
Thiodiphenylamine 0·1% and Soap ..	13·7		
Lead arsenate Paste 0·4%	27·5		
Unsprayed controls	36·0		
Derris 0·1% and Soap	5·6	1·8	15·7
Unsprayed controls	30·3	7·5	

Lead arsenate paste at 0·4% did not reduce the infestation. Thiodiphenylamine at 0·1% showed some promise but was inferior to Derris at 0·2%. The lower concentration of Derris (0·1%) gave practically as good a result as the higher (0·2%).

Crop records showed that Derris increased the yield by about 28% (Table IV), despite a heavy set of plums on all trees.

TABLE IV.

Spray Treatment.	Crop.
Derris	118·8 lb. per tree.
Thiodiphenylamine ..	96·6 ,, ,, ,,
Lead arsenate	78·1 ,, ,, ,,
Unsprayed	92·7 ,, ,, ,,

CONCLUSIONS.

These trials show that a single spraying of Derris can give substantially as good a result as two sprayings. They also suggest that Derris and soap can be successfully applied at any time during the seven to ten days following petal-fall—an important consideration where a large acreage has to be sprayed.

Derris is more likely to be effective against Red Spider if applied towards the end of this period, when all or most of the winter eggs have hatched. Where Spider is severe, however, the best course is probably to add a summer petroleum emulsion to the Sawfly wash since Derris alone cannot always be relied on to give a good control of Spider.

In one of the trials a Derris and soap wash containing the equivalent of about 0·002% crystalline rotenone reduced a Sawfly infestation of 30% to less than 6%. This result suggests that a satisfactory control can be obtained with concentrations of Derris much lower than that normally employed.

Several workers, including Dotti (1) and Petherbridge and Thomas (4), have carried out successful trials with quassia and soap. The preparation of this wash is, however,

somewhat cumbersome and, until satisfactory extracts are readily available, quassia is unlikely to replace Derris as a means of controlling Plum Sawfly.

Summary.

In field spraying trials on the control of Plum Sawfly (*Hoplocampa flava* L.) on Czar plums, one spraying with Derris gave substantially as good a result as two sprayings.

Derris at 0·2% (equivalent to a crystalline rotenone content of 0·004%) gave, in conjunction with soap, an adequate measure of control if applied at any time during the seven to ten days following petal-fall, differences in the date of application within this period having very little effect on the result.

An unusually low concentration of Derris (equivalent to about 0·002% crystalline rotenone) gave very promising results.

Nicotine, at 0·05%, and lead arsenate paste, at 0·4%, were each ineffective, whilst a preparation of thiodiphenylamine, at 0·1%, was only partially successful.

Acknowledgements.

The authors are indebted to their colleague, Dr. H. Shaw, who carried out chemical analyses of the Derris used, and to the various growers who kindly provided facilities for some of the spraying trials.

References.

(1) Dotti, F. "L'infuso di legno quassio nella lotta contro le Hoplocampa del susino." Rivista di Frutticultura, 1937, **1,** 59-88.

(2) Kearns, H. G. H., Marsh, R. W. and Martin, H. "Combined Washes. Progress Report. III." Long Ashton Res. Sta. Ann. Rep. for 1936 (1937), 99-117.

(3) Petherbridge, F. R. and Thomas, I. "The Control of Plum Sawfly." Journ. Min. Agric., 1936, **42,** 1,108-18.

(4) ——— "Spraying for Plum Sawfly." Journ. Min. Agric., 1937, **44,** 858-65.

(5) Sprengel, L. "Die Pflaumensägewespen." Zeit. für angew. Ent., 1930, **16,** 86 pp.

(6) Tonini, G. "Alcune prove di insetticidi." La Romagna Agricola e Zootecnida, 1932, **26,** 266-9.

FIELD TRIALS IN 1937 OF THE FUNGICIDAL AND PHYTOCIDAL PROPERTIES OF CERTAIN SPRAYS USED AGAINST APPLE SCAB

A PROGRESS REPORT

By M. H. MOORE

Introduction.

The chief aim of this work is to determine whether successful modifications can be made in the present routine spraying programme for Scab-control either by adjustments in the concentration of sprays commonly used, or by the use of addenda to these sprays, or by the development and use of new spray-fluids. A further point under consideration is the timing of the applications in relation to the strength at which the sprays are used. Progress reports on this series of investigations, dealing with the work done in 1935 and 1936, have already been published (2a, 2b).

The tests are made on normally-grown bush trees of Worcester Pearmain, Allington Pippin and Newton Wonder, in their tenth year in 1937, and all on No. IX stock. Certain comparable Edward VII trees, included in the original randomized planting arrangement, have proved of little use in these trials ; they were therefore stub-grafted to Cox's Orange Pippin in spring, 1937, and will be ready for inclusion in the 1938 tests.

The Trial.

The sprays were each applied at four periods in the growth of the trees :

(*a*) green-bud (21st April).
(*b*) pink-bud (4th May).
(*c*) petal-fall (27th May).
(*d*) three weeks later (16th June).

A small, 2 h.p. mobile outfit was used, and sprays were applied at 300-350 lb. per sq. in. pressure through a lance carrying a "double" nozzle fitted with $\frac{3}{64}$ in. discs. The outfit was towed behind a horse or a tractor, while a hessian screen was manipulated to arrest spray-drift.

The following sprays were tested :

Those containing sulphur.

(i) Lime-sulphur, specific gravity 1·3 ; polysulphide sulphur, 25% weight in volume. Used at **1% by volume, pre- and post-blossom.**

(ii) "Sulsol", a 42% (nominal 40%) colloidal-sulphur preparation. For fuller description see (2b), page 260. Used at **0·5% by weight, post-blossom only,** following 1% lime-sulphur at green and pink-bud. The content of elementary sulphur (0·2%) in the diluted spray was therefore approximately the same as that of polysulphide sulphur in (i) when diluted.

(iii) Tetramethylthiuram disulphide, a pure organic substance that contained 53·3% total sulphur, and showed distinct promise in laboratory tests of fungicidal

properties (3). Used at **0·02% by weight, post-blossom only,** following 1% lime-sulphur at green- and pink-bud. This is forty times the lowest concentration effective under laboratory conditions.

Those containing copper.

(iv) Bordeaux mixture, 0·1% copper sulphate and 0·15% hydrated lime by weight ; i.e. the formula **1-1½-100, pre- and post-blossom.**

(v) Bordeaux mixture as (iv) with the addition of washed cotton-seed oil,* **0·75% by volume, pre- and post-blossom.**

(vi) "Bouisol", a 15% colloidal-copper preparation. For fuller description see (2b), page 260. Used at **0·167% by weight, pre- and post-blossom.** The copper content of the diluted spray was thus equal to that (0·025%) in (iv) and (v) respectively, and the spray concentration was just one-half of that recommended by the makers.

The "buffer" trees, on the headlands at each end of the plot, were sprayed **at all four periods with Bordeaux mixture at 6-9-100** for comparison with those sprayed with the weaker mixture, though this comparison does not fall strictly within the limits of the statistically planned trial.

Nicotine at 8 oz. per 100 gal. was added to each spray at petal-fall to control Sawfly. The control trees, otherwise unsprayed throughout the growing season, received nicotine in water at this period.

General Observations.

The deposit left by the Bordeaux-oil spray was, characteristically, composed of small, isolated, heaped-up spots of spray-fluid. That given by the other sprays was typical of the ordinary spray without a spreader—more or less isolated spots of uneven size, shape and depth.

Weather Conditions.

The year was noteworthy in general for more than average rainfall during the first six months. In particular, the greater part of April was warm and showery with less than average sunshine ; the second and third weeks of May were cool, dull and very wet, and June was, on the whole, a very wet month. July was dry, rather cool and dull, while August was dry, warm and sunny. Conditions were, therefore, very favourable for early infection and the rapid development of Scab, although dry weather in the latter part of the summer tended to check this.

Spray-Injury.

The following notes were made during the season :

13th May.

Trees at approx. full bloom. Small, inconspicuous, brownish spots on foliage of copper-sprayed trees, especially Allington, except where cotton-seed oil used. A well-marked feature, on Allington, of unsprayed control trees and of those sprayed with Bordeaux-oil is the greater size of the rosette leaves—with all other treatments Allington rosette leaves are much smaller, presumably

* The oil was vigorously stirred into the copper sulphate dissolved in a little water, and the mixture added to the lime suspended in the bulk of water in the spray-tank. The value of cotton-seed oil used in conjunction with Bordeaux mixture has already been pointed out by Martin and his co-workers at the South-Eastern Agricultural College, Wye.

as a result of pre-blossom spray-treatments. This can be regarded as a form of spray-injury, although not accompanied by any obvious marginal leaf-burn, which, through subsequent curling, might make the leaf appear to be smaller than it really is.

7th June.

Still no obvious burning of foliage by any of the treatments. Allington fruits appear to be russeted by all copper sprays, the weaker ones being as harmful as the stronger.

28th June.

Slight leaf-drop on Newton with lime-sulphur (1%) used post-blossom. Russeting of fruits with all copper sprays now much more pronounced and especially conspicuous on Allington. Severe leaf-drop on Allington and Worcester sprayed with " Bouisol ", while the other copper sprays have so far caused no appreciable foliage injury.

7th July.

Bordeaux (6-9-100) on " buffer " trees only—slight leaf-drop on Allington and Worcester and yellowing of the older Newton leaves. Worcester leaves covered in purple spots, fruits of this variety and of Allington badly cracked and russeted. Newton fruits not badly affected. " *Bouisol* "—leaves and fruits of Allington and, to a less extent, Worcester, covered with small, purplish-brown spots ; also fairly severe leaf-drop. Not much damage on Newton. *Bordeaux* (1-1½-100)—purple-spot type of russet on Allington and Worcester fruits, very little on Newton. Moderate leaf-burn and leaf-drop on Allington and Worcester, none on Newton. The weaker spray is so far more harmful to foliage than the stronger. *Bordeaux* (1-1½-100) *with cotton-seed oil*—a very pronounced difference in foliage between this and the preceding ; here the leaves are larger, dark green and healthy, and there is no drop. Allington fruits show russeting, partly of the purple-spot type but mainly reticulate. *The Sulphur Sprays*—no injury apart from slight leaf-drop on Newton sprayed post-blossom with lime-sulphur (1%).

21st July.

Very severe leaf-drop now on " buffer " trees (Bordeaux 6-9-100). This stronger Bordeaux evidently is as harmful to the foliage as the weaker one, but the appearance of symptoms is delayed. No further damage by any of the other sprays. Recent growth of russeted fruits has caused many to crack and some of these are already infected with Brown Rot (*Sclerotinia fructigena*) (See 5, p. 283.).

Apple Scab.

Infections were first noticed on the rosette leaves of Allington control trees on 7th May, when they were at approximately " half-bloom ". Infection probably occurred about the third week of April, so that the green-bud spray, applied on 21st April, was ideally timed. Thorough search failed to reveal infections on any of the sprayed trees at this period ; several were found, however, on 13th May at full-bloom, almost invariably on the " wood-bud " leaves produced laterally to the rosettes. These leaves had, of course, developed since pink-bud and were therefore unprotected. A spray in bloom seems to be the only method of dealing with such infection, and experiments to test

the efficacy of this are being undertaken. By 7th June Scab had obtained a thorough hold on unsprayed trees, the young fruits and leaves of Allington being especially badly attacked. Worcester leaves showed little infection although many fruits were already heavily spotted ; the tendency for Worcester fruits, like pear fruits, to become infected before the leaves has frequently been observed. Certain sprayed trees, especially those with " Bouisol " or weak Bordeaux alone, showed a fair degree of infection which must have become established during the blossom period. There was no Scab on the " buffer " trees, and little or none on those sprayed post-blossom with Bordeaux-oil or lime-sulphur. A further general survey made on 7th July showed that all spray-treatments had considerably reduced infection ; the stronger Bordeaux and lime-sulphur (1%) throughout were superior to the other sprays in this respect, " Bouisol " and the weaker Bordeaux without oil being the most inferior. The use of cotton-seed oil had evidently improved the fungicidal effect of Bordeaux 1-1½-100.

Recording.

All small, dropped fruits were picked up and graded for Scab and Sawfly from the time they were large enough to handle and grade conveniently, i.e. from about mid-June onwards. Records were made of Codling and Scab on the larger dropped fruits, including windfalls, as well as on the picked fruits; windfalls nearing maturity were regarded as picked fruits for recording purposes. As usual, picked fruits were graded into categories of Scab and the " Scab-equivalents " were assessed by the method described elsewhere (7). The degree of russeting on Allington was assessed by similar means (8). Worcesters were picked on 30th August and 7th September, and Newtons and Allingtons during the first week of October.

Results.

The data are given in the table. With few exceptions, each value is an average for four similar trees of each variety. The following abbreviations are used :

L.S.—lime-sulphur, T.M.T.D.S.—tetramethylthiuram disulphide.

B.M.—Bordeaux mixture, C.S.O.—cotton-seed oil.

The concentrations of the sprays used are set out on pages 229-230.

Discussion of Results.

The Crop. The set* of fruit on most trees was very satisfactory ; the indifferent set on a few trees was due to causes other than spraying, and, in general, the spray-treatments caused but little fruit-drop. It is not easy to assess accurately the effect of spraying on the amount of crop for the number of fruits that reach maturity on unsprayed control trees is always depressed to some extent by Scab-infection ; fruitlets that become infected early tend to drop on that account. Hence the best standard of comparison is not necessarily the control trees but rather those on which Scab is well controlled by a spray-treatment known not to cause fruit-drop. Taking this into consideration, it is reasonably certain that lime-sulphur applied pre-blossom (treatments (*a*), (*b*) and (*c*)), caused slight loss of crop on Newton (column 12) and, moreover, that this effect was slightly increased by a post-blossom lime-sulphur spray (*a*). There are indications that post-blossom lime-sulphur caused slight fruit-drop on Allington (col. 6 (*a*)). Of the copper sprays, weak Bordeaux without oil had a slight depressing effect on the crop of Newton (col. 12 (*d*)) and " Bouisol " on that of Worcester (col. 1 (*e*))

* " Set " is here used to denote the production of recognized fruitlets.

Spray Treatment.	Worcester.					Allington.			
	(1) % fruit picked.	(2) Scab-equiv. (picked fruit).	(3) % of small "drops" scabbed.	(4) % Codling.	(5) % Sawfly (whole crop).	(6) % fruit picked.	(7) Scab-equiv. (picked fruit).	(8) Russet-equiv. (picked fruit).	(9) % of sma "drop scabb
(*a*) L.S. : L.S.	52·2	0·4	3·7	7·9	3·8	63·5	6·5	18·1	4·(
(*b*) L.S. : "Sulsol"	55·9	4·8	3·9	5·1	5·9	75·6	7·2	13·4	6··
(*c*) L.S. : T.M.T.D.S.	45·7	4·8	5·1	5·7	5·3	69·2	6·7	15·9	4·8
(*d*) B.M. : B.M. (1–1½–100)	46·1	6·5	6·0	6·3	17·2	57·4	19·8	22·5	13·4
(*e*) "Bouisol" : "Bouisol" ..	37·7	5·9	9·0	6·1	6·1	71·5	17·7	38·4	15·7
(*f*) B.M. ; c-s-o. : B.M. ; c-s-o. .. (1–1½–100)	54·3	3·3	3·7	7·8	4·4	64·5	9·7	32·6	7·7
(*g*) Controls (unsprayed) ..	**50·1**	**20·1**	**16·6**	**7·2**	**9·2**	**67·3**	**59·8**	**4·8**	**34·9**
(*h*) B.M. : B.M. (6–9–100) on buffer trees only	44·6	0·4	6·5	3·6	5·6	71·8	3·6	26·2	9·(
Average for variety (All treatments)	48·3	5·8	6·8	6·2	7·2	67·6	16·4	21·5	12·1

			Newton.					Average for Treatment (all varieties).				
ll s " ed.	(10) % Codling.	(11) % Sawfly (whole crop).	(12) % fruit picked.	(13) Scab-equiv. (picked fruit).	(14) % of small " drops " scabbed.	(15) % Codling.	(16) % Sawfly (whole crop).	(17) % fruit picked.	(18) Scab-equiv. (picked fruit).	(19) % of small " drops " scabbed.	(20) % Codling.	(21) % Sawfly (whole crop).
)	3·3	2·4	39·8	0·5	3·4	6·0	10·2	51·8	2·5	3·7	5·7	5·5
'	3·0	1·4	45·1	1·2	3·2	6·8	12·7	58·9	4·4	4·6	5·0	6·7
)	2·6	2·5	46·5	2·8	0·8	4·3	16·5	53·8	4·8	3·6	4·2	8·1
.	1·8	3·7	43·6	1·8	2·7	10·7	25·2	49·0	9·4	7·4	6·3	15·3
'	3·1	3·6	41·7	0·5	6·9	6·4	14·9	50·3	8·0	10·5	5·2	8·2
'	2·5	1·8	49·2	3·1	6·8	4·2	9·5	56·0	5·4	6·1	4·8	5·2
)	**3·7**	**2·5**	**48·3**	**13·8**	**12·9**	**6·0**	**23·4**	**55·2**	**31·2**	**21·5**	**5·6**	**11·7**
)	2·1	1·6	49·8	0·7	2·5	5·4	9·0	55·4	1·6	6·3	3·7	5·4
	2·8	2·4	45·5	3·1	4·9	6·2	15·2					

and Newton (col. 12 (*e*)). A noteworthy point is the relatively high percentage of fruit picked on Worcester and Newton trees sprayed with weak Bordeaux with cotton-seed oil ((*f*), cols. 1, 12). As regards varieties, it will be seen that the percentage fruit picked was much higher in Allington than in Worcester or Newton.

Fruit-russeting. General observations on russeting have already been set out above. Detailed records were made on random samples of Allington fruits at picking time, however, and a summary of these will be seen in column 8. It is clear that all the copper sprays proved unsafe ; " Bouisol " caused most damage, with Bordeaux-oil next. It is curious that the presence of cotton-seed oil should be of great advantage in eliminating foliage injury, yet it actually increased russeting ; an explanation may be forthcoming after further experience with the combined spray. The stronger Bordeaux caused little, if any, more russeting than the weaker. Worcester and Newton fruits showed similar reactions to those of Allington, although on Newton the russeting was only slight.

It was very surprising to find an inferior skin finish (apart from Scab) on fruit from sulphur-sprayed Allington trees (col. 8 (*a*), (*b*), (*c*)) in comparison with those from controls (col. 8 (*g*)). This was not all composed of the normal kind of russeting but partly of a form of split lenticel (see Fig. 1) very common in this variety, and partly of fine reticulate cracks in the skin (superficial russeting). In an earlier report (4) it was stated that the fungus *Coniothecium* is always associated with the symptoms but its parasitism is doubtful. Inoculation experiments with the fungus obtained from the skin of affected fruits have not been successful in reproducing the condition, and this is the first occasion on which the writer has been able from available data to associate this particular type of skin finish on Allington with spray-treatment. It is suggested that, in so far as spraying* is responsible for this condition, lime-sulphur applied *pre*-blossom and probably that at pink-bud is primarily concerned, and that the petal-fall application may help. Support for this hypothesis is obtained by comparing col. 8 (*a*) and (*b*), and a further experiment is planned to test this point. Representative fruits were selected and photographed to illustrate the degree of russeting found under the different treatments. (See Fig. 2.)

Apple Scab (*Venturia inaequalis* Cooke (Wint.)).

(i) *On picked crop.* Allington control trees were very heavily infected (col. 7 (*g*)) while those of Worcester (col. 2 (*g*)) and Newton (col. 13 (*g*)) were only moderately infected. Weak Bordeaux (*d*) and " Bouisol " (*e*) each gave indifferent control, but the Bordeaux was improved by the inclusion of cotton-seed oil (*f*), though even here the control was not perfect. The improvement was probably due largely to increased deposition and retention of the fungicide on the host plant in the presence of the oil, as shown by Martin (1). Shaw and Steer (9) have shown that the deposition and retention of lead arsenate is increased in the presence of *petroleum* oil. There was not much difference in fungicidal efficiency between the three sulphur spray programmes, (*a*), (*b*) and (*c*), on Allington. All gave good control, though lime-sulphur pre- and post-blossom (*a*) proved rather more efficient on Worcester and Newton than lime-sulphur followed by " Sulsol " (*b*) or by tetramethylthiuram disulphide (*c*). As might be expected, the stronger Bordeaux (*h*) was the most efficient fungicide.

(ii) *On small, dropped fruitlets.* The data on these reflect, in general, the position as shown by the Scab-equivalents on the picked crop. With the weaker Bordeaux (*d*), the fruitlets were less infected than, perhaps, would be anticipated, particularly on

* There is reason to suppose that the condition of the tree, as governed by factors such as soil type, manurial treatment, weather conditions, etc., may be partly responsible.

Worcester (col. 3 (*d*)) and Newton (col. 14 (*d*)). It will be seen later that there was more than an average amount of Sawfly on these fruitlets, and it is feasible to suppose that they were thus induced to drop before they became infected.

As with the picked crop, fruitlets on Allington control trees were much more heavily infected than those on Worcester or Newton control trees.

Codling (*Cydia pomonella*). The infestation was very light although specific measures were not taken to control it. There is no consistent evidence that any of the treatments affected the incidence of the pest. Allington was more lightly infested than either Worcester or Newton, but this is probably an indirect effect of the much greater crop on Allington.

Sawfly (*Hoplocampa testudinea*). Nicotine was applied on all trees at petal-fall specifically for Sawfly control. In spite of this, there were clear differences in infestation as between fungicide treatments. Nicotine in weak Bordeaux without oil (*d*), and, to a less extent, in water only (*g*), failed to give as good control as when it was included in the other sprays. This was especially so on Newton which was more heavily infested than either Worcester or Allington. As for Scab control, the presence of cotton-seed oil in weak Bordeaux with nicotine was beneficial also for Sawfly control : indeed, this combination gave the best control of all, while nicotine in weak Bordeaux alone gave the worst. Nicotine was as effective in the stronger Bordeaux as in the weaker Bordeaux with oil. It would appear that the explanation of these differences may be concerned to some extent with the physical properties of the different sprays, but the possible direct influence of fungicides on Sawfly control must not be forgotten. It has already been shown that the incidence of Sawfly is influenced by spraying with Bordeaux mixture or with lime-sulphur without nicotine, and with or without lead arsenate (6), but as one of the aims in these trials of fungicides is necessarily to eliminate insect attack as much and as uniformly as possible, any attempt to follow up these indications must be made from the entomological point of view.

Summary.

The fungicidal and phytocidal properties of weak sprays containing sulphur or copper are described. Each spray was applied twice before and twice after blossom to ten-year-old bush trees of Worcester Pearmain, Allington Pippin and Newton Wonder on No. IX rootstock. Very good Scab control was given by lime-sulphur at 1% throughout and was accompanied by only slight leaf- and fruit-drop on Newton. "Sulsol" (0·5%) and tetramethylthiuram disulphide (0·02%) showed distinct promise as post-blossom sprays following lime-sulphur (1%) pre-blossom. Neither caused damage, but the use of lime-sulphur resulted in poor skin finish on Allington. Weak Bordeaux mixture (1-1½-100) and "Bouisol" (0·167%) each gave indifferent Scab control and caused severe spray damage shown as leaf-burn, leaf-drop, and fruit-russeting. The inclusion of washed cotton-seed oil (0·75%) with the weak Bordeaux improved Scab control and obviated leaf-burn and leaf-drop, but failed to prevent fruit-russeting. A stronger Bordeaux (6-9-100) gave the best Scab control but caused severe injury. Newton Wonder was more resistant than the other varieties to injury by the copper sprays. Allington Pippin was the most susceptible of the three to Scab ; the control trees were heavily infected. None of the treatments showed any effect on Codling, but an influence of the fungicides was shown in Sawfly control. A petal-fall application of nicotine (0·05%) was less effective in weak Bordeaux, or water, than in any other of the treatments. The inclusion of cotton-seed oil with nicotine and weak Bordeaux greatly improved the control. Newton Wonder was the most susceptible variety of the three to Sawfly.

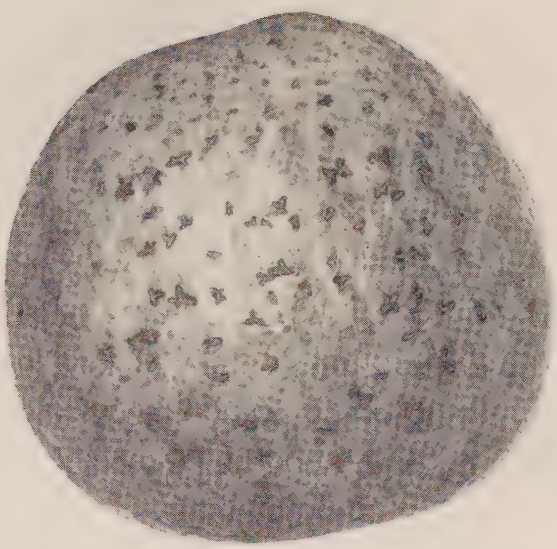


Fig. 1.

Split lenticel and poor skin finish on Allington Pippin, thought to be partly associated with lime-sulphur spraying.

FIG. 2.

Representative samples of Allington Pippin under each of the spray treatments. The numbers correspond in series to the letters prefixing the spray-treatments in the table of results. Unsprayed control fruits (No. 7) were chosen free from severe Scab so that this should not mask the superior skin finish.

References.

(1) Martin, H. "Studies upon the copper fungicides. II. Some modifications of Bordeaux Mixture designed to overcome practical difficulties in its application." Ann. Appl. Biol. 1933, **20,** 342-63.

(2a) Montgomery, H. B. S., Moore, M. H. and Shaw, H. "Field Trials in 1935 of the Fungicidal and Phytocidal Properties of Certain New Chemical Preparations." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1935 (1936), 198-203.

(2b) ——— "Field Trials in 1936 of the Fungicidal and Phytocidal Properties of Certain New Chemical Preparations." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1936 (1937), 259-66.

(3) Montgomery, H. B. S. and Moore, M. H. "A Laboratory Method for Testing the Toxicity of Protective Fungicides." Journ. Pom. and Hort. Sci., 1938, **15,** 253-66.

(4) Moore, M. H. "Investigations on *Coniothecium*." A Progress Report. E. Malling Res. Sta. Ann. Rep. for 1928-30, II. Supplement (1931), 150-6.

(5) ——— "Further Studies on the Incidence and Control of Apple Scab (*Venturia inaequalis*) and Apple Mildew (*Podosphaera leucotricha*) at East Malling." Journ. Pom. and Hort. Sci., 1932, **10,** 271-94.

(6) ——— "Some Incidental Effects of Routine Scab-Sprays, with Special Reference to Apple Fruit Sawfly Control—a Sidelight on the Interpretation of Field Spraying Experiments." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 90-8.

(7) ——— "Spraying Trials against Pear Scab (*Venturia pirina*). Some Practical and Theoretical Aspects of the Interpretation of the Results." E. Malling Res. Sta. Ann. Rep. for 1932 (1933), 99-108.

(8) ——— "Some Observations on the Influence of Manurial Dressings and of Certain other Factors on the Incidence of Scab (*Venturia inaequalis* (Cooke) Wint.) and of Spray-injury in Apples." Journ. Pom. and Hort. Sci., 1936, **14,** 77-96.

(9) Shaw, H. and Steer, W. "Spray Residue Investigations. II. The Influence of Spray Supplements on the Retention of Lead Arsenate on Apples." E. Malling Res. Sta. Ann. Rep. for 1937 (1938), 219-222.

Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

WINTER PRUNING OF APPLE TREES

SOME ADVICE BASED ON THE EAST MALLING EXPERIMENTS

By N. H. GRUBB

THOUGH the methods of pruning tested in the East Malling Apple Pruning Plot were adapted from the then current practice of growers in various districts, and were applied rigidly, without variation from year to year, and not in the more flexible way which the trial itself proved to be necessary, their results have made it possible to draw certain very definite conclusions. Some general advice based on these conclusions and on a few later results may perhaps be welcome.

In a tree's early years pruning has the aim of providing stout branches suitably placed for a good framework, i.e. to shape the tree. It is clear that this cannot apply to mature trees ; whatever the objects of pruning mature trees, they cannot be the same. Experience has shown also that different varieties require somewhat different treatments, and that long lived permanent trees may be better with more severe pruning while young than quick cropping " filler " trees. Pruning must therefore vary in both degree and method with the age, variety and purpose of the tree. Even in maturity pruning must vary ; the tree's condition and performance are the best guide to its needs.

As far as pruning is concerned, the tree's life can be conveniently divided into three periods : (1) the early years of framework formation, (2) the time of getting the tree into bearing, and (3) its maturity. These periods are not, of course, clearly separated ; they merge into one another, and vary considerably in their actual and relative length in different circumstances.

1. THE EARLY YEARS, BEFORE CROPPING.

This stage was not adequately dealt with in the East Malling trials. The trees were all cut hard and similarly for two years after planting, before the different pruning treatments were started. Consequently, a good framework was at least begun, even where the trees were afterwards left entirely unpruned ; and the shape of these unpruned trees was undoubtedly more similar to that of the regularly pruned trees than it would otherwise have been.

Nevertheless, there was enough difference in shape between the pruned and unpruned trees to show the value of at least more shaping than the unpruned trees received. The regularly pruned trees were always more manageable, in all such work as spraying, picking and cultivation, than the unpruned trees.

Thus, although the trial hardly justifies drawing definite conclusions as to the pruning in this early period, some advice can be based on it.

Except with cordon trees (or any trees planted close together for quick cropping) it is obviously very important to get an adequate proportion of the space occupied by trees as soon as possible. Until the trees occupy, say, half or more of the space allowed them, a heavy crop per acre is scarcely possible.

Now the East Malling Trial has shown quite definitely that leader tipping in this early period, when not complicated by very early cropping, makes the trees smaller, i.e. although the shoots of a tipped tree are always longer than those of a similar untipped tree, they are not enough so to make up for the parts cut away. It follows that in this early period we should always do as little leader tipping as will give us the kind of tree we want ; and that we should choose a form of tree which can be produced with a minimum of tipping, provided it will give satisfactory results in this climate.

This question of the best tree form is at present very open. The East Malling trial, not having been designed for the purpose, throws little light on it. It seems to the writer probable that in the comparatively sunless climate of the British Isles a fairly open tree form will be best, at least for coloured varieties, even at the expense of somewhat more tipping than may be required for a less open form. At the present stage he can hardly say more.

Whatever the form, the question often arises as to the best number of leaders to leave. One often hears pruners remark " we will leave it now and cut it out next year if necessary ". It is usually found that next year more courage is required to cut it out than would be needed at present. Such pruners often let their trees become overcrowded ; and where coloured varieties are concerned this may be a serious matter. The present writer prefers to err, with such varieties, on the other side, leaving the tree too open rather than too close. But there is little material from the East Malling trial with a bearing on this point.

Surplus laterals have also to be dealt with. It has been customary in the past to cut clean out all the stronger unwanted laterals, " too strong to spur ", and frequently to leave uncut a large proportion of the remainder. This is usually satisfactory except where conditions favour very quick cropping ; which brings us to our next period.

2. Beginning Cropping.

In the writer's experience, trees left entirely unpruned have always in their early years produced much more *blossom* than similar trees branch pruned in any way whatever ; but trees lightly thinned out without leader tipping do sometimes produce more *fruit* (from less *blossom*) than unpruned trees. The pruned trees set their blossom better than the unpruned ; and this is found to be a very frequent result of pruning, especially with mature trees, though the instances of more fruit from less blossom are not so common. In general it may be said that winter branch pruning, and especially leader tipping, reduces or delays cropping as well as blossoming. Severe tipping may even delay it by several years.

Obviously we do not usually want to delay cropping more than we can help. But there are exceptions. Where conditions—rootstock, variety, soil, etc.—favour very early cropping, the tree's growth may be seriously checked before it has reached an adequate size. Relatively weak growing varieties, like Cox's Orange, when worked on Metz Paradise (IX), are often apt to overcrop while very small ; unless they are planted very closely, it is essential in such cases to reduce their crop drastically, in order to let them grow. Leader tipping will do this ; but it may have to be so severe that the trees

would increase in size scarcely more quickly than if left untipped and allowed to crop. In such cases, blossom removal is probably the best remedy, coupled with such light leader tipping as is necessary to keep the tree reasonably vigorous. As long as the trees are quite small, blossom removal is practicable on a commercial scale. But it must be the removal of blossoms only, and not entire fruit buds ; the individual flowers can be removed, a week or two before they open, the basal rosette of leaves being allowed to remain.

In other and more usual cases, where conditions favour growth rather than early cropping, pruning in this second period should aim as far as possible at hastening cropping, especially with " filler " trees. The leaders should be tipped lightly or not at all, and most of the outward laterals left uncut. Where cropping is unduly delayed, it is better even to leave the head of the trees too dense for a year or two, with a view to thinning it out after cropping has well started.

It has been found by some growers, also, that in some cases tying down the upper parts of the taller branches to a horizontal or drooping position, with little or no pruning, is commercially practicable. It is difficult to arrange this without interfering seriously with cultivation and other routine work ; but it is at least worth considering.

The East Malling trial has brought out certain other desirable results of leader tipping. Several varieties, when left untipped, fail to " furnish " their branches satisfactorily with spurs. The difference in this respect between the tipped and untipped trees of Worcester Pearmain in the Pruning Plot, 24 years after planting, is still quite obvious. Beauty of Bath is somewhat similar, whilst Cox's Orange and Grenadier show this difference much less clearly.

Certain varieties, and most varieties in certain conditions, also have weak branches which are much bent down by the weight of a crop. In this respect Cox's Orange is one of the worst. Leader tipping has definitely stiffened the branches ; the tipped trees are distinctly less pulled out of shape than the untipped.

For these reasons it may be advisable to tip the leaders of young trees lightly, even where it would be unnecessary otherwise.

In this second period the shaping still continues, even apart from the above considerations. Tipping the leaders to upward or outward buds according to varietal habit is now generally understood and need not be stressed. But the correct method of tipping to keep a tree flat headed is still sometimes reversed, so that the trees become more out of shape than before. Where certain branches tend to grow away from the rest of the tree, they should be tipped severely and the remainder lightly or not at all. Branches of the same tree do not behave entirely independently ; cutting one branch helps to some extent to invigorate others. Moreover, the part cut away has to be made up before the branch can grow taller. Cutting the weak side of a tree and leaving the strong, which the writer was taught to do in his youth, is exactly the wrong way to do it.

In this period, also, spur pruning needs considerable care. If unwanted laterals can be converted into fruiting spurs, so much the better. Some judgement is required to decide which laterals should be cut clean out, which spur pruned, and which left uncut. It may be said in general that the more nearly a tree is in full cropping, the better hope there is of converting even strong laterals into fruiting spurs. In the early years, except with very precocious trees, it may take several years to complete the conversion. Experience has shown that, at least in the conditions prevailing at East Malling, it is usually better to leave four or five inches of the lateral the first time it is cut, rather than to cut it shorter. It is not suggested, of course, that another four or five inches should be left in each subsequent year ; that would soon overcrowd the

tree with straggly spurs. After the first cut, one inch is usually enough to leave of any new shoots formed. The object is to reduce vigour of growth and eventually to cut the whole spur back to a fruit bud.

The tip-bearing of certain varieties, especially Worcester Pearmain, is now well known and usually allowed for by pruners. The method commonly applied to young trees of Worcester, of allowing many shoots with tip fruit buds to remain uncut, may well be applied to any slow cropping trees, even where tip fruit buds are uncommon. The shoots so left will usually form some fruit buds, to which the two-year shoot can be cut back.

3. Maturity.

That mature trees require frequent pruning, is now established beyond doubt. The bad effects, in one direction or another, of leaving such trees unpruned for more than a year or two have been amply demonstrated. If growing vigorously, the trees soon become overcrowded ; they are then difficult and expensive to spray properly, and when the pruning can no longer be neglected, it is a very costly job. If lacking in vigour, the trees are apt to produce much small fruit, and in many cases only light and irregular crops.

The recent performance and present condition of the tree, then, give the best guide to the pruning required. For the production of good crops of good fruit, the head must be kept open. Fortunately there is little risk, at this stage, of making a tree so much over-vigorous that it fails to produce enough blossom for a crop. Within wide limits, one can do what pruning one likes without seriously upsetting the balance of the tree.

But it is still more important, especially with Cox's Orange Pippin and similar varieties, to see that vigour is maintained. This can often be done by judicious pruning, but not always. It has been shown more than once that spur shortening, the removal of part of each long branching spur, not only increases fruit size, but invigorates the tree. Where this is not enough, a moderate or even severe " dehorning " may be called for. Cases are known where moderate dehorning, while reducing the amount of blossom, has greatly *increased* the crop, by making the blossom set better ; in some cases fruit size is also increased.

Growers should remember that though Cox's Orange is more apt to lose vigour than most varieties, even Bramley may do so, and may benefit greatly by reinvigoration.

It must be remembered also that pruning is not the only method of restoring vigour, and may not even be the best method. Under-vigorous trees, where not overcrowded, may need manuring rather than pruning ; and if they are in grass, cultivation for a year or two may be the best remedy.

Biennial Bearing.

Attempts to correct the biennial habit, by pruning and other methods, have been in progress for several years. It is now believed that this can be done, at least partially, by pruning chiefly in the winter following the crop, when fruit buds are few, with little or no pruning in the alternate year. The pruning should as far as possible be done by many small cuts, as, for instance, severe spur-shortening, which should be entirely omitted in the following winter. There is nothing so far to suggest that leader tipping or dehorning can be used to correct the biennial habit.

The fact that spur-shortening when fruit buds are few appears to check the biennial habit more than cutting away many fruit buds when they are numerous may seem

curious and contrary to expectation. The present writer cannot offer any satisfactory explanation. But it may be pointed out that the removal of fruit buds when they are dormant is by no means equivalent to the removal of individual blossoms, which can change the year of cropping. In the former case the rosette of leaves is removed ; in the latter it remains.

Finally, it has been shown by actual trial that in any spur-shortening, wherever more than occasional fruit buds are present, it is best to leave the largest and best developed buds, and remove the smallest. If cutting the spurs short involves removing the largest, it will always be better to leave the spurs longer and cut away the small buds instead.

Summary.

Some advice is given, based on the East Malling Apple Pruning Trials.

From the pruner's point of view, the tree's life may be divided into three periods.

1. *Before cropping.* The chief object is shaping and the production of a good framework. It is usually best to choose a form of tree and method of obtaining it which involve a minimum of leader tipping.

2. *Beginning Cropping.* This involves a gradual or rapid change over from growth to cropping as the chief function of the tree. Advice is given on the amount of leader tipping needed, the treatment of laterals and spur pruning, etc. in various cases.

3. *Maturity.* It is seldom satisfactory to leave a mature tree entirely unpruned for more than one or two years. The pruning required depends on the condition of the tree, and particularly its vigour. Vigour must be maintained ; this can often be done by pruning, but sometimes manuring and cultivation are more important.

The control of biennial bearing by pruning is briefly discussed.

THE FRAMEWORKING OF FRUIT TREES*

By R. J. GARNER and W. F. WALKER

Introduction.

As the years go by it is becoming more and more obvious that far too many varieties of fruit are being grown for the market. This state of affairs is due in part to the introduction of new promising varieties without any corresponding diminution of the number of those older and possibly less desirable. This is certainly so in the case of the earlier plantings and also, to some extent, in those of recent years. The same is true of almost all parts of the Empire where fruit is grown. Where fruit has to travel long distances in ships, it has been found that many of the varieties, previously grown, have not arrived upon the market in a satisfactory condition, and some of the remainder, though they may travel and store in good order, are not popular upon the market. Again it has been demonstrated that some, otherwise satisfactory varieties, are damaged by the sprays which are essential for the production of good fruit on that or an adjacent variety. Some varieties are more susceptible to attacks by fungi and insects. Such may not realize a higher price when marketed, and the extra cost of producing them in good condition may preclude the possibility of any profit.

In some of the earlier plantings, whole blocks of one variety were planted without a pollinator. As a consequence, such plantations are now only carrying moderate crops. Where two or more varieties have been planted together it is not infrequent to find that such varieties require entirely different treatment culturally. For example, one, a culinary variety, may need comparatively heavy dressings of nitrogenous manures and frequent soil cultivation, whilst the other, a dessert variety, requires little nitrogenous manure and almost no disturbance of the soil.

Other varieties may prove to be distinctly biennial bearers and not capable of producing sufficient fruit to warrant their retention. Furthermore, some varieties are unsuited to the environment in which they are grown. Though it is probably true to say that the public taste for certain kinds of fruit may be modified by efficient business methods, it is certain that fruit fashions have changed, or, possibly, that the public has been educated to prefer other varieties, and those previously in favour do not now sell sufficiently readily to enable them to be grown at a profit.

Thus there are many important reasons why fruitgrowers desire to change their present varieties to those which are proving to be more profitable. Varieties may be changed in two ways. They may be grubbed and replaced with the desired variety or the existing variety may be reworked. The removal and replanting of fruit trees is a costly process and should not be done unless the trees are very old and diseased or are known to take the new variety badly. Much work is entailed in removing established trees, new trees cost money and, when planted on ground recently occupied by mature trees, they not infrequently fail to make satisfactory growth.

Reworking—topworking and frameworking compared.

Fruit trees may be reworked in a variety of ways. Until a few years ago almost all of this reworking entailed the removal of the original top or head of the tree. This reworking process is generally known as topworking. In topworking, a tree may be

* Issued separately as Occasional Paper No. 5 of the Imperial Bureau of Horticulture and Plantation Crops, and reprinted here by permission of the Bureau.

deheaded more or less severely according to the size of the tree and the likes or dislikes of the grower. In some parts of the world the branch system, or framework of the tree, is cut back to within a foot or so of the main stem, whilst in other areas a greater length of the main branches may be left and the new variety then begins correspondingly further from the trunk (8, 16, 21). In all true topworking only the ends of the cut-back branches are worked with the new variety. The topworking of fruit trees is a comparatively simple process and proportionately inexpensive, but there are disadvantages. The removal of the branches upsets the normal balance of the tree and checks rootgrowth very severely (13). Should the operation be successful the growth from the new variety will be extremely vigorous, largely owing to the predominance of the roots, and little fruit-producing wood will be forthcoming for some years. Even when the first fruits are borne upon newly topworked trees they usually prove to be outsize, poorly coloured, lacking in finish and often susceptible to bitter pit, and do not store successfully.

As much as ten years, according to variety, may be required before the tree returns to profitable cropping. In removing branches the formation of large wounds is unavoidable and these require some years in which to heal. Such wounds need frequent re-sealing in order to ensure that diseases do not enter the tree through these points. It was due to disease organisms entering through these large wounds, that improved methods of reworking apple trees were resorted to in Tasmania from 1922 onwards (23).

Since 1927 notably in Tasmania (2, 18, 19, 20, 21, 23), latterly in Victoria (7, 17, 24, 25), and England (3, 11, 12), an entirely different reworking technique has been developed. This technique, with modifications, is now employed both experimentally and commercially in many fruit areas of the Empire (4, 6, 10, 15). It may be noted, in passing, that there is still nothing new under the sun, for Thomas Andrew Knight (14) in a paper given before the Horticultural Society in London on May 18th, 1813, dealing with the culture of pear trees, wrote as follows with regard to a fan-trained St. Germain pear : " To attain these purposes every branch which did not want at least 20° of being perpendicular, was taken out at its base, and the spurs upon every other branch, which I intended to retain, were taken off closely with saw and chisel. Into these branches, at their subdivisions, grafts were inserted at different distances from the root, and some so near the extremities of the branches, that the tree extended as widely in the autumn, after it was grafted, as it did in the preceding year. The grafts were also so disposed, that every part of the space the tree previously covered was equally well supplied with young wood."

It has already been suggested (12) that the term " frameworking " may be applied to all methods of reworking which involve the retention and use of the complete framework of the tree. Thus, methods of reworking may be divided into two, (*a*) topworking and (*b*) frameworking. It is unfortunate that other less suitable terms have been used by some workers. The term " porcupine " grafting was first used to describe one particular method of frameworking (15, 17), and proved adequate for that technique. Since then, however, the term " porcupine " has been used indiscriminately to describe very different methods and confusion has occurred. In England (3) the term " herring bone " grafting has been used to describe the appearance of the inserted scions. Since, however, the adoption of a system of frameworking likely to prove successful would not give a " herring bone " appearance, the use of this expression is deprecated.

Development of frameworking technique.

Some of the earliest methods of frameworking fruit trees consisted of light to moderate deheading of the limbs, followed by whip-and-tongue and rind-grafting of

spurs, laterals and small secondary branches arising from the framework of the tree (2, 18, 19).

Where the spurs were too weak for grafting they were removed and bark grafts were placed direct on to the limb (23). Experience proved this to be more satisfactory than waiting till summer and then budding shoots which arose from these areas.

Frameworking by the "multiple-bud" (11, 18, 19) system was undergoing tests from 1927 onwards. In this method the entire framework was cleared of all spur and lateral growths during the winter or early spring. Unwanted shoots which arose from the framework were removed, and the remainder were budded with the new variety in summer.

This method was slower than grafting and the shoots to be budded did not always arise from the most desirable places on the framework. It was at least a year before the scions made their first growth and, owing to the nature of such growth, the return of the tree to normal cropping was delayed.

A year after these first trials the whole framework was cleaned up as in preparation for budding, but inverted L bark grafts were inserted. These grafts were held in place by means of a $\frac{5}{8}$ in. flat-headed nail of 19 gauge, and no tying was necessary. This method was found to speed up the work considerably and an earlier fruiting tree was obtained (23). One man, with a boy to tack and seal the grafts, completed between 80 and 100 grafts per hour. Other methods of frameworking, which avoid the use of tying materials or tacks, have been developed. The stub-graft and side-graft, both cleft-graft types, are good examples (12).

The "chisel", "plug" or "peg" graft also does not require tying or tacking, but this method has proved unsatisfactory and has been unfavourably reported upon by Leishman (15), Thomas (21) and Walker (23).

The advantages of frameworking.

There are distinct advantages to be gained by the use of frameworking. Owing to the retention of the branches little disturbance to the balance of the tree occurs and consequently the health of the tree is not impaired. The removal of large branches and the formation of large wounds is avoided and, partly owing to the health of the tree, the numerous small wounds are completely healed during the first season after grafting. Thus there are few or no open wounds for the entrance of disease organisms. In some parts of the world the formation of large wounds by the removal of branches is almost invariably followed, sooner or later, by the death of the tree, and in those districts frameworking has been the only method of reworking that is possible (19, 23).

Further advantages of frameworking are that, in retaining the whole framework of the tree, all the growth from the new scions goes to form fruiting wood and to extend the tree, whereas in topworking a new framework has first to be produced in order to carry new crops, and extension of the tree is not possible until the original framework has been entirely replaced.

Perhaps the most obvious advantage is that frameworked trees very quickly return to profitable cropping. Numerous varieties grown in Tasmania have returned to heavy and continuous fruiting eighteen months after grafting. Some varieties, in the same country, have not returned to full cropping until the third season after grafting and this appears to be the general experience in England with the varieties that have been tried. This variation in the time taken to crop is due to varietal habit and local conditions.

Possibly the only disadvantage in frameworking is the greater cost of the operation compared with topworking. This may have deterred some growers from employing

frameworking, but, as will be seen later, this extra cost is not so formidable as has been supposed.

FOUR PRACTICAL METHODS OF FRAMEWORKING.

Methods of frameworking may be divided into two:—(*a*) cleft-grafts and (*b*) rind-grafts. These last entail the separation of the rind from the wood of the tree. This is not possible until the late spring when the rind parts readily from the wood. In the south of England the rind is not readily lifted until the beginning of April in normal seasons. Similarly in Australia, rind-grafting of pears may be started in August (corresponding to March in England) and that of apples about three weeks later. However, the time is largely governed by local conditions. On the other hand, cleft-grafting, which does not depend on the separation of the rind from the wood, may be

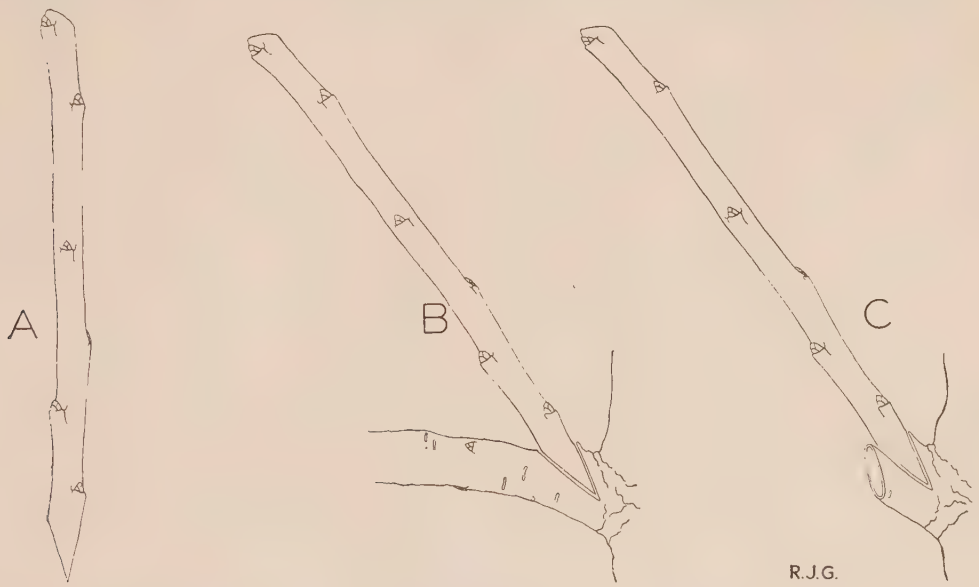


DIAGRAM 1.
Stub-grafting.

carried out much earlier in the season. In England cleft-grafts inserted during February have proved very successful. Frameworking has given good results as late as July at East Malling, but late grafting is not advocated.

The four methods now to be described are two cleft-grafts and two rind- or bark-grafts. The stub- and side-grafts, with the oblique side-grafts, are of the former type and the bark- and awl-grafts are rind-grafts. Scion wood, for all four methods, is collected whilst dormant and stored in a cool moist place until the time of grafting.

(1) *Stub-grafting.*

This method was first used in frameworking at East Malling in 1932 since when, after slight alteration, it has become one of the most popular methods in England. The tree to be grafted is cleared of lateral growths except small lateral branches varying from $\frac{1}{4}$ in. to 1 in. in diameter, which are retained wherever it is desired to have lateral branches of the new variety. This work may be carried out at any time during the dormant season prior to grafting.

The scions are prepared with their basal ends in the form of a wedge as shown in Diagram 1 A. One side of the wedge receives a slightly longer cut than the other. The lateral branch to be grafted receives a cut on its upper side commencing about half an inch from the main branch and extending to the base almost as far as the centre of the lateral shoot. Care must be taken to ensure that the cleft does not extend beyond the centre of the shoot, otherwise the " spring " of the cleft is weakened and the scions will not be held sufficiently firmly. This cut is opened by bending down the lateral and the prepared scion is inserted as illustrated in Diagram 1 B with the longer side of the wedge downwards. It is essential that at least a portion of the cambial tissue of the scion should be in contact with that of the lateral branch into which it is inserted. In order to achieve this when inserting scions into large laterals, it is necessary to place the scion to one side of the cleft. The lateral is released and cut off immediately above the insertion of the scion as depicted in Diagram 1 C. Upon first attempting this

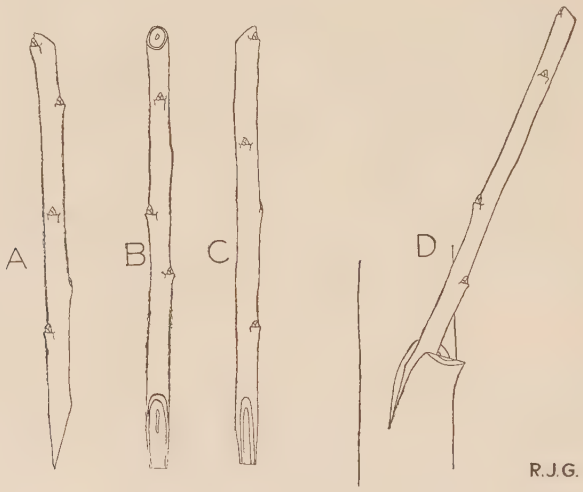


Diagram 2.
Side-grafting.

operation some difficulty may be experienced, but by the use of a good knife, and after a little practice, it is satisfactorily accomplished. The terminal shoot on each main branch is cut off at the time of grafting, at a point immediately above the uppermost stub-graft. The sealing of all cut surfaces completes the operation.

Frameworking by stub-grafting has proved successful with apples, pears, plums and cherries.

(2) *Side-grafting.*

This method was developed and used on a large scale in West Sussex, England, by Mr. W. Fowle in 1934 and was described by Garner (12). The scions are inserted direct into the limbs of the tree without recourse to the use of lateral shoots. Comparatively small limbs are more easily side-grafted than those of large size.

The trees are prepared by removing all the lateral shoots before grafting and the whole framework is then worked with side-grafts. Alternatively, the best placed laterals may be left and stub-grafted and only the intermediate portions of the limbs furnished with side-grafts.

The scions are prepared with the basal end in the form of an unequally sided and comparatively long wedge. In preparing the scions advantage should be taken of the slightly " zig-zag " nature of the shoots in order that the scion, when inserted, may stand away from the framework branch as much as possible, so that the angle is approximately that of lateral shoots. The prepared scion is depicted in Diagram 2 A, B and C. A cut is made into the side of the branch, at an angle of about 20°, never deeper than one-quarter of the diameter of the branch. The cut is opened by slight bending of the branch and the scion is inserted so that its cambium is in contact with that of the framework. The thin lip of bark raised from the branch prior to inserting the graft is cut off as shown in Diagram 2 D after the scion has been pushed home. In order to complete the graft it only remains to seal the exposed cut surfaces.

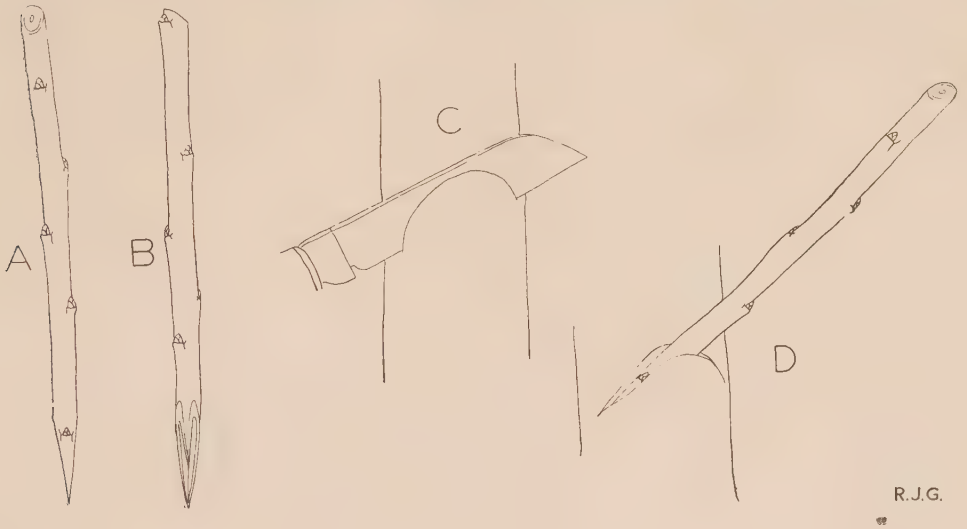


Diagram 3.
Oblique Side-grafting.

A modified side-graft, known as the oblique side-graft, has been developed in Tasmania, see Diagram 3, but it has not yet been tested at East Malling. The ease with which it is accomplished and its successfulness under Tasmanian conditions warrant a description of it here. The scion is prepared as in Diagram 3 A, B, with two sloping cuts about one inch long made on two sides of the basal end of scion, and in such a manner that the two cuts meet longitudinally on one side at an angle of 30° to 45°. A shallow oblique cleft is made in the side of the limb as in Diagram 3 C. This cleft should be slightly deeper than the lateral wedge at the base of the scion. The knife is then partly removed from the cleft to allow the toe of the scion to be inserted. When the scion has entered the cleft, the knife is removed and the scion wedge is then pushed right across the cleft. After sealing the wound the operation is complete. This side-graft has proved to be very suitable for working large limbs where the bark is often very thick.

It is important to remember that in side cleft-grafting the cambial tissues of scion and stock must be in contact with each other. Side-grafting has proved successful in England with apples but has not, so far as is known, been applied to other fruits on a commercial scale.

(3) *The inverted* L *Bark-graft Method.*

This method of frameworking is especially popular in Tasmania where it has been developed upon the fruit farms of Messrs. Frank Walker & Sons of Lalla. It has been used extensively since 1930 in that and other countries (4, 7, 11, 12, 15, 17, 23, 25). Bark-grafts must be performed when the bark is lifting freely. All lateral shoots and spurs are removed from the tree before grafting begins. The scion is prepared by first making one sloping cut of about 1½ ins. in length at the basal end followed by a very shallow cut at one side just sufficient to expose the cambium as shown in Diagram 4 A. The scion is then reversed and a smaller and more shallow cut than the first is made a little to the side of the scion away from the small second cut as in Diagram 4 B. The limb to be grafted now receives a cut as depicted in Diagram 4 C. The term " inverted L " does not accurately describe this cut. In the diagram it will be noted that the

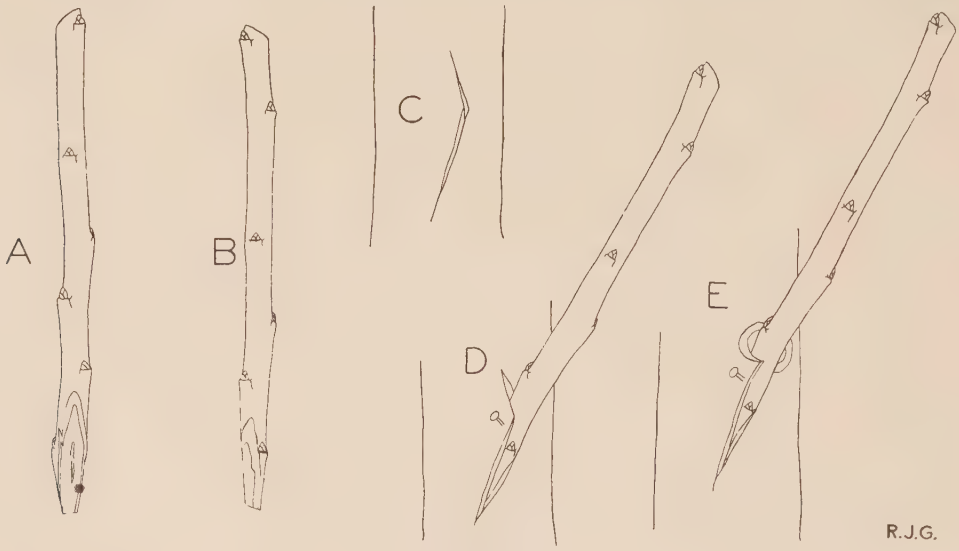


Diagram 4.
Inverted L Bark-grafting.

longer, or lower, cut is not made in line with the limb, as this would cause the scion to lie along the limb at an unnatural angle, but is so made that the scion stands away from the surface of the limb. The top cut in the bark is not made at right angles with the lower one but more nearly approaches 150°. It is also cut obliquely into the bark thus enabling the scion to enter beneath the bark more easily and to fit snugly into position. This modification of the inverted L method allows the raised bark to fit closely on to the scion. The scion is inserted as in Diagram 4 D and is held firmly in position by a flat-headed nail of 19 gauge and ⅝ ins. in length, which is driven right home through the bark and scion into the wood. Should the bark of the limb be abnormally thick, ¾ ins. nails are used of the same gauge. It has been found that stouter nails tend to split the scion. Scions may be placed immediately below wounds caused by the removal of lateral shoots, or spurs, as in Diagram 4 E. Scions so placed assist the rapid healing of the wounds and the sealing of the graft seals the wound, so saving both time and material. In sealing this type of graft it is especially important to ensure that water cannot enter between the scion and the limb. Bark-grafts have proved

successful with apples and pears in Tasmania and with apples at East Malling, where the method has not yet been tried on other fruits to any great extent.

(4) *Awl-grafting.*

This method has been developed in Tasmania but up to the present it has only been tested on a small scale at East Malling and a few other centres in England.

The method is extremely simple to carry out but it is as yet doubtful if it is so successful as those previously described. The tree is denuded of laterals as for inverted L bark-grafting. The scions are prepared as in Diagrams 5 A, B and C. The larger cut Diagram 5 B, which is eventually placed next to the wood of the limb, may be slightly concave with advantage, as it has to fit upon the convex surface of the wood. The smaller cut

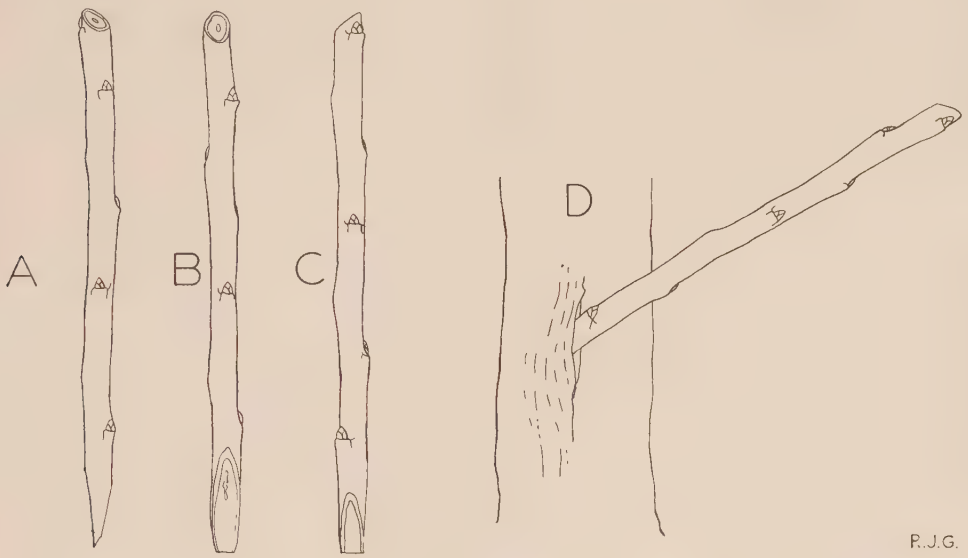


Diagram 5.
Awl-grafting.

as shown in Diagram 5 C is made in order to enable this part of the scion to join on to the bark of the limb.

A chisel-bladed tool is now inserted through the bark and between it and the wood of the limb to be grafted. The tool should enter the bark from an angle of some 20° to 30° above the horizontal. The tool is removed and the prepared scion inserted in its place as shown in Diagram 5 D. All cut surfaces are immediately sealed. Various tools have been used for awl-grafting. One of the best is that made from a small screw-driver slightly curved. Another is made from a sacking-needle by grinding the point away to a chisel end and fixing the eye end of the needle into a convenient handle similar to that of an awl. In some places (7) a large penknife type of blade with the point sharpened on both sides is used to make the required incision.

The terminals of the limbs of trees frameworked by rind-grafting methods, such as the bark- and awl-grafts described above, may be rind-, cleft- or whip-and-tongue grafted to complete the work. The grafts should be sealed as in the other methods described.

Number and length of scions.

The scions are spaced according to the purpose in view. In Tasmania scions have often been placed 6 to 10 inches apart, arranged around the limb as are laterals and spurs on trees before reworking. Care has also been taken to avoid positions endangered by cultivation implements. Under English conditions growers have placed scions much wider apart, sometimes as much as 12 inches, in order to reduce costs. With wide spacing it is necessary to treat the new growths from the scions as fruiting lateral branches in order to obtain sufficient fruiting area. This wider spacing of the grafts has probably in part accounted for the rather slower return to fruiting experienced in England. A well developed ten to twelve-year-old bush or half-standard apple tree could be furnished with from eighty to one hundred scions at 10 to 12 inches apart. Well grown thirteen-year-old standard Newton Wonder trees at East Malling were fully furnished with a hundred and fifty scions of Laxton's Superb, spaced some 8 inches apart. Fig. 3. See also Fig. 1, showing a twenty-year-old Gladstone tree frameworked with 120 scions of Worcester Pearmain. A similar distribution of scions is seen in Fig. 2 A. In Tasmania very large twenty to thirty-year-old apple trees have required up to one thousand scions, at 6 inches apart, to refurnish them, in cases where the complete framework has been retained.

Experience has proved that the length of the scions when grafted is of great importance. On 5th March, 1811, T. A. Knight communicated to the Horticultural Society the fact that grafts inserted into old pear trees " may be made to afford fruit next year ; but for this purpose the grafts must remain nearly as long as the longest scions I send " (14a). Growth from the newly inserted scions is almost always extremely vigorous and scions containing only two or three buds usually produce three vigorous shoots which are not likely to bear fruit for two or three years. By the use of longer scions containing six to eight buds, vigorous growth is reduced or only occurs from the upper two or three buds of the scion, as shown in Fig. 2 B. The lower buds eventually form fruit buds or short fruiting branches. In all the methods of frameworking described in this paper, long scions should be used, never having less than six buds and preferably seven or eight.

The exercise of care in the placing of scions.

It is very important that scions should be placed in the best positions. There is much to be said for the spiral arrangement of scions provided this arrangement is not adhered to too strictly. Downward pointing scions, where they are likely to be damaged by cultivators, should be avoided, and so should positions directly on top of the limbs, especially on the outside of a bend, as almost invariably extremely vigorous growth is made in these positions, to the detriment of shapeliness of the tree. The placing of scions near the crutch of the tree does not permit of their proper development and it is suggested that scions should not be placed nearer to the crutch than 18 inches or 2 feet, except in some orchards overseas where thorough shading of the crutch of the tree is necessary in order to avoid sun-scald. The fitting of scions should receive care, as large and ugly callus growths, and also weak unions, may be attributed to faulty workmanship. Often operators are so surprisingly successful that they become careless, only to find, that a few seasons later the results of irremediable faults become evident.

The choice of graft seals and wound dressings.

The covering of wounds should be a simple operation, and is doubtless considered so, seeing that this work is usually assigned to boys or unskilled workers. It is therefore

interesting to note that experienced grafters attribute most failures to careless or inefficient sealing. Suitable materials for sealing framework grafts come under three heads (*a*) hot grafting wax, (*b*) various grades of petroleum jelly, (*c*) certain bitumen emulsions. The writers are aware that many other materials have been used for sealing tree wounds, including cold waxes, dissolved in spirit or sufficiently pliable to be applied as received from the makers. Those tested have either proved too expensive for framework grafting or too difficult to apply rapidly. Waxed cloth and tapes are sometimes used, but, as all the practical methods of frameworking do not require tying, the holding property of the fabric is not required and also proves wasteful where it is necessary to lap the fabric upon itself after having encircled the framework branch.

Hot-grafting-wax.

Many good hot waxes are used in various parts of the world. They are usually cheap, being made on the farm, quickly applied and fairly stable in hot weather. A hot fire is required for quickly heating and re-heating the wax in the field and this may be obtained by burning coke or charcoal in a pail, or small drum, in the sides of which numerous holes have been made for ventilation. Paraffin lamps are also commonly used for heating grafting wax. A hot wax which has proved efficacious at East Malling is made from the following ingredients in the proportions given.

	lbs.	ozs.
Resin	5	0
Burgundy pitch	1	10
Tallow	1	4
Paraffin wax	1	4
Venetian red	1	8

First melt the resin and Burgundy pitch, then add the paraffin wax and 1 lb. of the tallow. Melt all these together stirring all the time. When the whole is melted and just boiling *take the vessel off the fire* and stir in the Venetian red. Have a vessel of cold water ready. *Well grease the hands with the spare tallow ;* then pour a portion of the mixture into the vessel of cold water and pull it about as though making toffee, until all the materials are well mixed.

If the Venetian red is warmed, before stirring into the melted wax, the air content of the powder will be much reduced and there will be less risk of the material effervescing and overflowing.

Petroleum jelly.

In Tasmania and some of the cooler regions of Australia, a dark, crude form of petroleum jelly has been used for sealing grafts and covering wounds (20, 23). This jelly is cheap, easy to apply and appears to encourage a very satisfactory callus. It remains quite stable and is not affected by normal climatic fluctuations. In extremely hot weather, with direct sunlight, there is a danger of petroleum jelly melting and running down the limbs. This melting in strong and direct sunlight, besides giving an unsightly appearance, has been regarded as causing death of bark tissues. It is apparent that there are several forms of petroleum jelly and it is most essential that the heaviest and most crude form is used, as lighter forms, by melting during hot weather, have been the cause of losses amongst grafts.

As petroleum jelly remains in a more or less tacky state for several years it has proved troublesome, in sticking to fruit, leaves and to the clothes of pickers and pruners (22).

In many cases this has been due to the excessive amounts used in sealing a graft or wound, but, at the same time, this excess of jelly has been most effective in preventing woolly aphis (*Eriosoma lanigerum* Hausm.) from damaging the tissue, in the region of grafts and wounds. It also appears to smother the eggs of the red spider (*Oligonychus ulmi* C. L. Koch) so often found around the base of laterals.

If it were possible to evolve a petroleum mastic which would gradually harden and flake off after three or four months, it would be more suitable than the permanently sticky petroleum used at present. Various mixtures of petroleum jelly with substances such as solid paraffin, powdered inert solids and drying agents, are under test at East Malling and it is hoped that, in the near future, one or more of these mixtures will prove suitable for sealing framework grafts.

Soft materials, such as petroleum jelly, have not proved so successful for sealing stub- and side-grafts as those materials which set hard. These latter cement the scion into position and help to prevent dislodgement by birds and other agencies.

Bitumen emulsions.

These materials are now available on the market specially prepared for dressing tree wounds and for sealing grafts (3). They are particularly useful for dressing wounds as they exhibit excellent covering power and are quite harmless to trees. They are not entirely successful, in our experience, in covering gaps between the scions and the limbs of the tree and it is quite often necessary to coat over these gaps more than once before a permanent seal is made. The bitumen emulsion sets in the presence of air and it is necessary to avoid exposing the liquid in bulk. Before setting, the emulsion may be thinned with water, as desired, and care must be taken to wash out brushes at intervals and when ceasing work. Unless definitely guaranteed to be harmless to trees, bitumastic paints and waterproofing materials should not be used indiscriminately as some of these contain materials which quickly kill plant tissues. It is reported that bitumen emulsions have given variable results in Tasmania (20).

" Colas " and starch mixture.

This preparation has proved very successful in Victoria (25) and is more reliable in the hotter districts of Australia (23) than mastics which become liquid when the temperature rises. In a paper published by the Victorian Department of Agriculture (25) the following formula is given. " Gradually stir one tablespoonful of powdered starch into 1½ pints of warmed ' Colas ' until the former is ' cooked ' and the mixture is smooth and of an even consistency. If the mixture is too thin it will run into narrow spaces between the scion and the limb and also away from the graft. If thick, it will not cover well and will set too quickly for easy application. More starch should be added to thin mixtures and more ' Colas ' to those which are too thick."

THE APPLICATION OF THE METHODS.

Growers are sometimes a little doubtful as to the graft they should employ. Should the grower be less busy during February, March and early April than he is likely to be in late April and May, he would be well advised to use the stub- and side-graft, both of which are cleft-grafts. However, it should be remembered that the stub-graft is only practicable when the tree to be grafted has sufficient well placed laterals or spurs. Some varieties, particularly when they have not been tipped each year, often possess bare limbs ; it is then impossible to employ the stub-graft, and the side-graft must be used. In practice, frameworking early in the season calls for the employment of both stub- and side-grafts on the same tree.

Large limbs devoid of laterals lend themselves best to rind-grafts such as the bark- and the awl-graft. By the employment of methods which require limbs devoid of laterals, the preparation of the trees is so simple that it may well be left to unskilled labour, thus allowing the more skilled to concentrate upon the actual grafting.

In the frameworking of stone-fruit trees it is generally found that there is difficulty in raising the bark until late in the grafting season and therefore it is suggested that cleft-grafts should be employed where possible.

After-care of frameworked trees.

Upon completion of frameworking operations upon trees in cultivated ground it will be found that the soil is in urgent need of cultivation owing to the treading of the grafters.

As the spring advances sucker shoots will arise from the main branches of the old variety, and these should be rubbed out when the longest are between 3 inches and 6 inches in length. At this time many of the shoots likely to arise will be removed and it may not be necessary to remove any further shoots until the time of the annual winter pruning. It is sometimes necessary to remove sucker shoots twice during the first season after grafting but never more than twice. If sufficient scions have been used, very few suckers arise in later years and these, if they do appear, can be removed, during winter pruning operations.

The pruning of frameworked trees.

The pruning of newly frameworked trees should be governed by the age and size of the trees, the graft population, that is, whether many or few per unit length of framework, the shape of the tree and the fruiting habit of the variety. Young trees which have not yet filled the space allotted to them, will have received a small number of grafts which will be pruned more or less heavily with a view to the extension of the branch system. Larger and older trees, for which there is no further room for development, will be pruned to encourage the earliest possible return to profitable cropping. In almost all cases light pruning should be the rule. Growths from widely spaced grafts will have room for development into fruiting laterals and it will only be necessary to remove shoots that are severely interfering with others. Generally speaking it is better to remove vigorous shoots entirely either by cutting them out at their point of origin or by jointing back the scion to immediately above the next shoot below. Moderate or hard spurring at this stage results in numerous growths and consequent delay in the formation of fruiting wood. Wherever possible, as on the outside of the tree, shoots should be left their entire length until the production of fruit-bearing wood.

In some fruit areas of the Empire apple trees are trained with open centres and a small number of branches, often twelve or fourteen, which are spur-pruned throughout their length. Refurnishing the framework of such trees calls for the insertion of scions at short intervals, usually 8 to 10 inches apart. Growth from closely spaced grafts is weaker than that from those more widely spaced and a more severe method of pruning may be practised with success. It seems evident that the amount of sunlight has a direct bearing upon fruit-bud formation and frameworked trees in sunny districts are likely to respond to more severe pruning than that generally advocated for trees in England. The return to cropping is largely controlled by variety. Under Tasmanian conditions the apple varieties Granny Smith, Tasma Pride and Sturmer Pippin have returned to full cropping with the loss of only one season, whilst the varieties Democrat and Crofton have required three seasons after grafting before bearing normal crops.

Worcester Pearmain has proved slightly later than Granny Smith and Tasma Pride in returning to full cropping. In England the varieties Grenadier, Worcester Pearmain and Laxton's Superb have cropped rather more quickly than Cox's Orange Pippin.

Costs and returns.

The cost of frameworking varies greatly in different parts of the world and is largely governed by the spacing of the scions and the size and shape of the tree, and also by the amount of ladderwork required. Owing to the comparatively large number of grafts used in frameworking, as compared with topworking, the cost of the former is considerably greater, though the cost per graft is very much less. On medium sized trees, involving a proportion of ladder work, English growers' costs for frameworking, including preparation of the tree, clearing away prunings and making wax, have worked out at 1s. 9d. to 2s. 6d. per hundred grafts. Scion-wood is usually collected from the grower's own trees, or from those of a friend, at pruning time, and is not included in the above figures.

In Australia and Tasmania similar trees have cost from 1s. 3d. to 2s. 3d. per hundred scions according to variety and method of grafting.

Those who have frameworked large numbers of trees are firmly of the opinion that the extra cost of frameworking is more than repaid by the rapid return of the trees to profitable cropping, and the avoidance of losses due to diseases which so frequently follow upon ordinary topworking.

In Fig. 3 is shown a Newton Wonder apple tree worked in 1935, at thirteen years old, with one hundred and sixty-five stub-grafts of Laxton's Superb. This tree in 1937 carried five bushels of excellent fruit which was marketed at an average price of twelve shillings per bushel.

A ten-year-old cherry tree at East Malling, frameworked with ninety scions in 1935, carried thirty-three pounds of large fruit in 1937. Trees of Utility plum frameworked with about one hundred scions of the varieties Czar and Victoria bore eighty pounds and sixty pounds of fruit respectively during the second season after grafting.

In Australia the returns have been greater. For example large Pomme de Neige trees averaging between five hundred and seven hundred scions of Granny Smith apple have cropped at the rate of from ten to twelve bushels of fruit eighteen months after grafting and these trees continue to yield normal crops (23). Pear trees have also been frameworked with success. Normal cropping, as with the slower cropping varieties of apples, begins two and a half years after working.

Varietal incompatibility.

So far there appears to be no conclusive evidence of any incompatibility between old and new apple or pear varieties when frameworked. It is thought by some that certain varieties of pome fruits have remained abnormally weak when grafted upon the framework of other varieties but the writers are not aware of any conclusive evidence of this being true in all cases where such varieties are grafted together.

The frameworking of stone fruits has not yet been extended to many varieties, but in view of the possibility of growers wishing to rework unprofitable varieties of plum in the near future a warning should be given. Past work at East Malling (1) and elsewhere (5) has shown that definite incompatibilities exist between certain varieties of plums and the plum rootstocks upon which they are worked. For example, the plum variety Czar has proved incompatible with some rootstocks and the same is true of the reciprocal graft (9). On the other hand, many plum varieties, indeed all those tested

at East Malling, have made satisfactory unions with the rootstocks Pershore (syns. Yellow Egg or Pershore Egg). From this it would appear to be safer to work various varieties upon trees of Pershore than upon trees of Czar and therefore growers, unless they have evidence to the contrary, would do well to anticipate trouble, when frameworking upon such varieties as Czar, by testing no more than a few trees in the first instance. Chang (9) has shown that the degree of compatibility between varieties may be measured by applying tests to the union after one season's growth.

Summary.

To change a variety for one which is more profitable the grower has a choice of reworking or grubbing.

Reworking is preferable to grubbing as being more economical except when the trees are too old.

Topworking and frameworking are compared; topworking is shown to be accompanied by certain disadvantages which are not met with in frameworking, while the great advantage of frameworking is the retention of health and the more rapid return to profitable cropping.

Four methods of frameworking, known as stub-grafting, side-grafting, inverted L bark-grafting and awl-grafting, are fully described, with diagrams.

The distribution, number and length of the scions are discussed. An imitation of the natural arrangement of laterals, and the use of long scions, are advocated, and the exercise of care when grafting is stressed.

Suitable graft sealing materials are classified under three heads, hot waxes, petroleum jellies, and bitumen emulsions. Recipes are given for one hot wax and a colas-and-starch mixture, and suitable petroleums are described.

The applications of the methods described is discussed. A programme of after-care is given and methods of pruning are suggested.

The costs and returns of frameworking in England and Tasmania are given and shown to vary according to the methods employed.

Growers are warned against the indiscriminate reworking of stone-fruits in view of the definite incompatibilities found to exist between certain varieties when grafted together in the nursery.

References.

(1) Amos, J., Hoblyn, T. N., Garner, R. and Witt, A. W. "Studies in incompatibility of stock and scion. Information accumulated during twenty years of testing fruit tree rootstocks with various scion varieties at East Malling." Ann. Rep. E. Malling Res. Sta. for 1935, **A19**, 1936, 81-99.

(2) Anon. "Top-grafting fruit trees." Tasmanian Mercury, March 1st, 1932.

(3) ——— "Modern methods of top-grafting fruit trees." Advis. Leafl. Norfolk C.C., 4, 1936.

(4) ——— "Porcupine grafting." Fruitgrower, 1936, **81**, 698.

(5) Argles, G. K. "Review of the literature on stock-scion incompatibility in fruit trees with special reference to pome and stone fruits." Tech. Comm. Imp. Bur. Fruit Prod., **9**, 1937.

(6) Black, M. W. and Micklem, T. "Topworking fruit trees." Fmg S. Afr., 1935, **10**, 295-6.

(7) Broadfoot, H. "Reworking established apple and pear trees." Agric. Gaz. N.S. Wales, 1937, **47**, 45-2 and 504-6.

(8) Cardinell, H.A. and Bradford, F. C. "Grafting in the apple orchard." Sp. Bull. Mich. Agric. Exp. Sta., **142**, reprinted February, 1929.

(9) Chang, Wen-Tsai. "Studies in incompatibility between stock and scion, with special reference to certain deciduous fruit trees." J. Pomol. 1938, **15**, 267-325.

(10) De Wet, A. F. and Micklem, T. "Topworking old fruit trees." Fmg S. Afr., 1936, **11**, 237-8.

(11) Garner, R. J. "A method of converting unprofitable fruit trees." Ann. Rep. E. Malling Res. Sta. for 1933, **A17**, 1934, 103-7.

(12) Garner, R. J. "The rapid conversion of unprofitable fruit trees by grafting." Ann. Rep. E. Malling Res. Sta. for 1935, **A19**, 1936, 204-9.

(13) Knight, R. C. "The influence of winter stem pruning on subsequent stem- and root-development in the apple." J. Pomol. 1934, **12**, 1-14.

(14) Knight, T. A. "On the culture of the pear-tree." Paper read before the Horticultural Society on May 18th, 1813. Printed in "A selection from the physiological and horticultural papers" published in the Transactions of the Royal and Horticultural Societies. Orme, Brown, Green and Longmans, London, 1841, 201-3.

(14a) ——— "A short account of some apples and pears, of which grafts were communicated to the members of the horticultural society." Trans. hort. Soc. London, 1812, **1**, 226-9.

(15) Leishman, E. "Reworking of fruit trees." J. Dep. Agric. S. Aust., 1936, **40**, 124-8.

(16) Middleton, M. S. "Topworking of fruit trees and propagation." Hort. Circ. Dep. Agric. B. Columbia, **42** (revised edition), 1928.

(17) Prescott, E. E. "Changing the variety of fruit trees—some modern methods." J. Dep. Agric. Vict., 1934, **32**, 517-22 and 535.

(18) Thomas, P. H. "Reworking of fruit trees." Bull. Dep. Agric. Tasm. **3** (new series), 1928.

(19) Thomas, P. H. "Converting the unprofitable fruit tree." Tasm. J. Agric., 1930, **1**, 198-202.

(20) Thomas, P. H. "The refurnishing of fruit trees." Fruit Cult. small Fmg, N.S.W., 1934, **4**, 44, 18.

(21) Thomas, P. H. and Raphael, T. D. "Reworking full-bearing apple trees." Tasm. J. Agric., 1933, **4**, 147-56.

(22) Vincent, C. L. and Luce, W. A. "Propagation of fruit trees." Pop. Bull. Wash. agric. Exp. Sta., **141**, 1928.

(23) Walker, W. F. "Simple methods of refurnishing unprofitable fruit trees." Fruit Cult. small Fmg, N.S.W., 1935, **6**, 62, 16 and **6**, 63, 25.

(24) Ward, J. M. "Budding, grafting and inarching of fruit trees." Bull. Dep. Agric. Vict. **63** (new series), being reprinted from J. Dep. Agric. Vict., **27**, 290-302, 396-406, 460-5.

(25) Ward, J. M. and Prescott, E. E. "Reworking, grafting and budding of deciduous fruit trees." J. Dep. Agric. Vict., 1937, **35**, 275-86.

[*Photograph by Kathleen E. Cornford*

FIG. 1.

A twenty-year-old Gladstone apple tree photographed immediately after frameworking with one hundred and twenty scions of Worcester Pearmain.

(A) (B) [*Photograph by Kathleen E. Cornford*

FIG. 2.

Two similar branches frameworked with the apple Cox's Orange Pippin.

(A) Newly inserted stub- and side-grafts. Note distribution of scions.

(B) After one season's growth. Note fruit-bud formation at base of long scions.

[*Photograph by Kathleen E. Cornford*

FIG. 3.

A Newton Wonder apple tree frameworked in 1935, at thirteen years old, with Laxton's Superb. Photographed in September, 1937, when bearing five bushels of fruit.

MYCOLOGY AND BACTERIOLOGY

VERTICILLIUM WILT OF HOPS

A SUMMARY OF INFORMATION FOR GROWERS

By R. V. HARRIS and B. S. FURNEAUX*

1. Distribution.

The disease was first discovered at Penshurst, Kent, in 1924, and numerous other cases have since been identified in Kent, Sussex and Herefordshire.

2. The Causal Fungus.

Its cause has been shown to be a fungus (*Verticillium albo-atrum*) belonging to a group commonly inhabiting the soil.

3. Mode of Infection and Injury to Hills.

Hop hills become infected in the first place *from the soil through their roots*, not from the air by spores. Thence the fungus permeates the underground root-stem system and later grows up through the water-conducting vessels into the bines, causing all or (more commonly) a proportion of them to wilt and die either after picking (when no loss of crop is caused) or before picking (from June onwards) when the disease becomes economically serious. In exceptionally severe cases the hill may be completely killed, but more commonly hills showing wilt in one season subsequently make partial or complete recovery, e.g. in the garden at Penshurst where the disease was first identified in 1924, *no wilt occurred* in 1937.

4. Distribution of the Causal Fungus.

A hill infected with the fungus does not necessarily develop severe (or even noticeable) wilt symptoms. Thus in severely affected gardens the fungus has been found not only in the hills with wilting bines but commonly also in apparently normal hills outside the severe wilt areas. It has also been isolated from Fuggle sets directly taken from the experimental garden at the East Malling Research Station where no case of wilt has hitherto been recorded. Therefore freedom from external wilt symptoms is not sufficient ground for pronouncing a hill free from infection by the fungus and, conversely, the development of such symptoms does not imply that the hill has become newly infected, i.e. that infection has newly spread from neighbouring wilting hills. An outbreak of severe wilt is, on the contrary, primarily brought about by the occurrence of certain weather and local soil conditions which favour a more active development of the disease in already infected hills.

5. Soil and Weather Conditions inducing Severe Wilt.

Surveys made to the present date have shown that the soil of the severe wilt areas of affected gardens are maintained in a wet condition not far below the surface,

* Soil Surveyor, South-Eastern Agricultural College, Wye.

owing to the presence of springs. The activity of the springs varies according to the seasonal weather conditions, but where the rainfall enables the springs to produce a high water table during the growing period, severe wilting is liable to occur. Thus it is that in any one garden, wilt may be severe one year and absent the next. This may also account for the fact that wilting may take place early, when the loss becomes severe, or it may occur late, i.e. after picking, and therefore not noticed. On the other hand, a high winter water table which recedes during the summer, such as is often encountered near streams, will not, in the absence of springs, cause severe wilting.

6. Control Measures.

(*a*) *New plantings.* Avoid soils with high summer water tables unless the springs can be adequately piped away from their sources following heavy and prolonged rainfall. N.B.—Winter flooding does not appear to affect the incidence of severe wilt.

(*b*) *Established plantations.* Improve the drainage system as far as possible to facilitate the rapid disposal of spring-water after periods of excessive rainfall.

(*c*) *Grubbing Wilted Hills.* For the reasons stated in (4) above it is unlikely that this measure will check the outbreak (or apparent spread) of the disease. Moreover wilt-hills commonly make partial or complete recovery. Where a hill has been completely killed, replanting may be successful and should be attempted, but in the exceptionally severe wilt areas or " patches ", newly planted sets commonly contract the disease and die during their first year.

(*d*) *Resistant Varieties.* Outstanding resistance to the disease has not yet been found in any variety.

The above general recommendations are based on the data it has been possible to collect up to the present time. The investigation, as yet in its early stage, must proceed further before a detailed schedule of control measures can be drawn up. In particular additional information is required on the following points :

(*a*) The distribution of the causal fungus.

(*b*) The critical soil conditions inducing wilt and the possibility of their amelioration.

(*c*) The relative susceptibility of varieties of hop.

Summary.

The results of research on Hop Verticillium Wilt (*Verticillium albo-atrum*), from the identification of the disease in 1924, to the present time, are summarized from the growers' point of view, and provisional control measures are enumerated.

WALNUTS

A SURVEY OF THE INVESTIGATIONS ON THE PROPAGATION AND TESTING OF WALNUTS AT THE EAST MALLING RESEARCH STATION

By A. W. WITT

EAST MALLING Research Station has been making a study of Walnuts since 1925. Following the methods adopted in other lines of work on tree fruits, varieties for scions and rootstocks have been collected from all over the world, and methods of propagating rootstocks, both as seedlings and by layering, of clonal selections of various species and varieties, have been studied. Methods of budding and grafting both in the open ground and under glass, are being investigated and experiments with soft-wood cuttings under glass have been tried. Trials of grafted walnuts are being carried out in different centres in England ; our oldest grafted varieties are now 10-11 years old and are beginning to give some interesting results with regard to their cropping and suitability for cultivation in Britain.

PROPAGATION.

Rootstocks.

Up to the present the chief rootstocks used for *regia* varieties have been one year seedlings of *J. nigra*, seed nuts of which are obtained from a single tree, and one year seedlings of *J. regia*, seed nuts of which are obtained from healthy trees growing in this country. In an endeavour to find other rootstocks suitable for walnut growing in this country we have raised clonal races of *J. regia*, *J. nigra*, *J. mandshurica*, *J. Sieboldiana*, *J. cinerea*, *J. regia himalayica* and hybrids, " Royal " (*J. regia* × *J. californica*), and " Paradox " (*J. nigra* × *J. californica*). These are all being raised by layering, the rooted layers being grafted to clonal scion varieties of *J. regia* to test their comparative values for growth, hardiness, time and amount of cropping, etc.

There are already indications that among them will be found suitable stocks for various soils and situations, and also for size of tree desired.

Juglans nigra forms several very strong roots, with a distinct downward tendency, and having comparatively little fibre. This stock transplants well with very few losses. As the main roots are usually very long, it is often advisable to cut off a third to a half of their length before planting, in order to avoid turning up the ends of the roots, for if this occurs new growth is very much delayed. Where walnuts are planted on land under cultivation, this stock should always be used, so that injury to the roots by cultivation is avoided.

Juglans regia has fewer very strong roots but usually much more fibre than *J. nigra*. A very nice stock but perhaps not suitable for cultivated land.

Juglans Sieboldiana, the so-called White Walnut with white bark, is comparatively shallow rooting, its strong roots having much fibre ; it roots freely from layers.

Juglans cinerea is somewhat similar to the preceding in habit of rooting and in the amount of fibrous roots. Both these stocks appear to be suitable for planting on somewhat shallow soils and are likely to produce trees of only moderate size.

Of the hybrids, " Royal " and " Paradox " present indications are that they will produce large vigorous trees.

Budding.

It appears evident that cold wet summers are not favourable to success in budding the walnut, as the " takes " have been very low in 1936-7. In previous years good " takes " were obtained in ring budding by using buds of the previous season's growth. This method is well worth trial on trees of poor varieties up to 25 years old, to convert them to better sorts. If only a few buds grow they usually make vigorous growth and refurnish the tree in 2-3 years. In the tree shown in Fig. 1, taken April, 1937, the stock is a seedling, *J. regia,* about 10 years old. Buds of the previous years growth were ring budded on to the main branches in May, 1935. These buds quickly started into growth and made shoots 20 inches long the same year. The budded branches were not cut back to the bud until the following February. It is important that cutting back be not done until the union is well lignified, otherwise the chambered pith is likely to admit dry air and this causes dying out of the growing bud.

Experiments in budding are being continued, buds being inserted at fortnightly intervals from end of May to mid-August into one-year-old shoots produced as the result of heading back.

Grafting.

Grafting under glass in March is still the most successful method of propagating the walnut, and can be relied on to give good results, always provided that sound scion wood is available. Grafting in July with young shoots with leaves will also give good results. It is necessary to place such grafts in a warm close frame and to maintain the leaves in a turgid condition ; a union is usually effected in about 14 days. Grafting in the open ground has proved to be very uncertain, particularly in seasons with wide changes of temperature. One tree about 25 years old situated in a very sheltered position was grafted in spring immediately after cutting back branches into which the grafts were inserted, with the result that only 8 per cent. grew. The following spring, grafts were inserted on the young shoots that grew as the result of cutting back, when 60 per cent. success was obtained and well refurnished the tree.

Pollination.

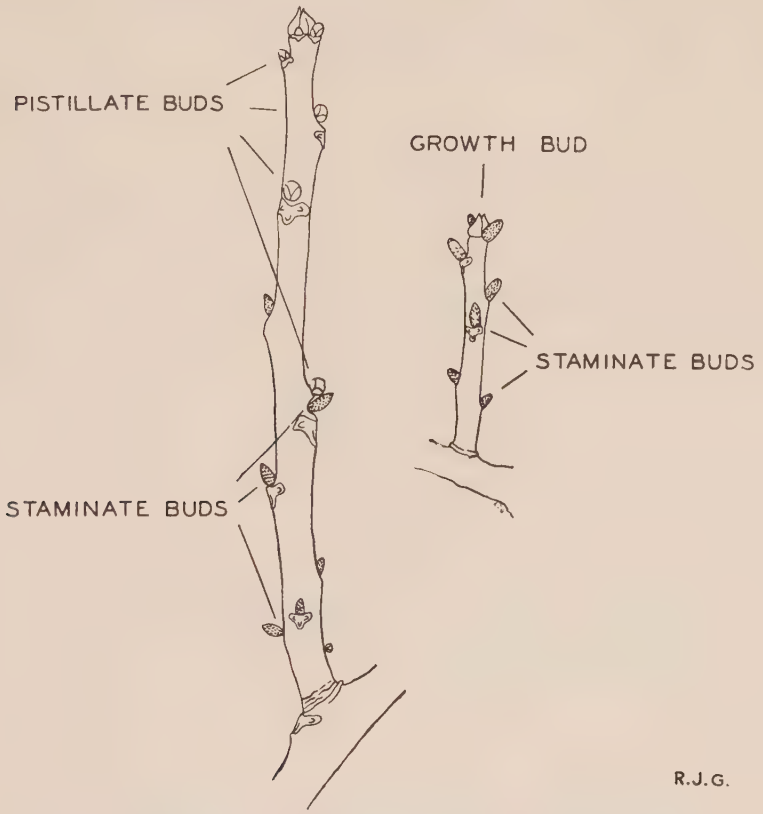
The walnut is monœcious, i.e. pistillate and staminate flowers are borne on the same tree. Both kinds are usually abundantly present on mature trees. On young trees pistillate flowers (nutlets) may occur at five years old but staminate flowers (catkins) in some varieties may be delayed as long as twelve years before they are produced.

In winter the different flower buds may be recognized. The pistillate are round plump buds at and near the apex of well ripened shoots. Staminate are more or less pointed and cone-like in shape and are found on thinner shoots below the apex. Occasionally a staminate flower may be present immediately below a pistillate flower at the same node (see text figure). Although on some trees both catkins and nutlets may be ready at the same time, thus ensuring efficient fertilization, in others pollen may be ripe as much as two weeks before the stigma is receptive. This is a point on which further research

is needed. The pollen is wind borne and may be carried from trees 400 to 500 yards, or more, distant.

Frost Injury.

Frost injury is one of the main limiting factors to the successful culture of the walnut in this country. From the time the bud-scales loosen and the leaflets become visible until the tree is in full leaf a period of about a fortnight may elapse. A bad frost at any time during this period may spoil the entire crop. The stigma is most susceptible



The arrangement of the buds of the pistillate and staminate flowers.

to frost injury, especially if early morning sun occurs. We have often observed that nuts are borne on the west side of the tree when those on the east side have been destroyed by frost. Sites with a due east aspect are better avoided for walnut planting. Even when the leaves are fully out they may be blackened by frost such as occurred in May, 1935. Hence the date of leafing-out is one of the most important things to know about any variety of walnut to be grown in this country.

From observations over a period of seven years of some English varieties consistently bearing good crops of nuts even in unfavourable seasons, we have invariably found them to be late leafing-out in the spring. The average time for leafing-out of the four varieties of French walnuts described below (Franquette, Mayette, Treyve and Meylanaise) is from 6th to 12th May and this should be safe in most English seasons.

Abnormal Nut Development.

In 1937 many native walnuts failed to develop the kernels and others were badly sealed and therefore quite unsuitable for storing. This was probably due to unfavourable weather conditions both in June and September of 1937. This emphasizes the importance of finding varieties which will not be adversely affected in this way.

Damage by Rooks.

It is not advisable to plant walnuts within half a mile of a large rookery. These birds attack walnuts chiefly during the first hour of daylight, just as the shells begin to harden about the second week of September. For pickling walnuts this does not apply as they must be gathered before the shells begin to harden.

Small Garden Trees.

Walnuts are sometimes required as quite small bush trees in a garden. Experiments to test such methods have now been in progress for five years with the result shown in Fig. 2. A small grafted tree is planted in fairly good, but not rich, soil. When the young shoots have made five or six leaves, the actual growing tip is pinched out by the finger and thumb. *A knife must not be used*, and not more than 1 cm. of the tip must be taken out. This treatment has the effect of causing the buds below the tip to plump up and become female flower buds. The thin weak shoots on the tree should not be touched as on these the male flowers will be borne. The pinching must not be delayed beyond the sixth leaf or else growth instead of flowers will result. Pinching should be done on all fairly strong shoots all through the growing season and every year. Should the tree persist in making too much growth, it should be entirely lifted in October, and immediately replanted *in situ*.

Varieties in the East Malling Collection.

The walnuts now collected at East Malling are all varieties of *Juglans regia*, except three American varieties of *J. nigra*, one of which is valued for its timber while the other two produce nuts used in confectionery. The varieties in the collection may be classified and briefly described as follows :

I. Varieties recommended for Planting in Britain.

(*a*) *French Varieties.*

Franquette. This variety grafted on either *J. nigra* or *J. regia* makes a large spreading tree, very late leafing-out, i.e. 6th-12th May. Pistillate flowers (nutlets) are produced at 5 years old, but staminate flowers (catkins) not until 4-5 years later. Profitable cropping may be reached at approximately 10 to 12 years when probably 20 lb. per tree or more husked nuts may be obtained. The nuts are of good contour with a pointed apex, medium to large size, well filled, and of excellent quality, averaging 30-35 nuts per lb.

Mayette. The above notes apply to this variety except that the nuts are smoother in contour with a blunt apex.

Franquette and *Mayette* are two of the " Grenoble nuts ".

Meylanaise. Late in leafing-out, growth more slender than Franquette, produces both kinds of flowers when quite young ; hence a good pollinator for other varieties.

Nuts roundish, medium size, good quality. In wet seasons some nuts may fail to ripen. Average 35-40 nuts per lb.

Treyve. Late in leafing-out, produces nutlets and catkins at an early age. Nuts of good contour and sealing, well filled with excellent meat. Average 30-40 nuts per lb. This variety has borne excellent nuts during the past two unfavourable seasons.

(*b*) *English Varieties.*

When the Royal Horticultural Society's Walnut Competition was held in London in November, 1929, the winning exhibitors were asked to supply scion wood, which we grafted. Our trees of these varieties are still too young to allow of detailed descriptions of their growth characters, and at this stage the descriptions given below can be only regarded as tentative.

Excelsior of Taynton (No. 95).* Medium size nut of good quality. 30-35 nuts per lb.

Champion of Ixworth (No. 162). Very good in contour, sealing, filling and quality. 25-30 nuts per lb.

Stutton Seedling (No. 202). Large, smooth thin shell, well sealed. Well filled with meat rather low in oil content. This is an attractive nut with many good qualities. 18-25 nuts per lb. It would probably make a good parent for breeding work.

Lady Irene (No. 589). Not a large nut but of good contour. 30-40 nuts per lb. Well sealed and filled with meat of high quality.

Northdown Clawnut (*J. regia maxima*) (No. 719). A good large double nut, well sealed, well filled with meat of high quality. 18-25 nuts per lb. The only double nut worthy of selection from many samples exhibited.

The foregoing nine varieties are being propagated in good numbers for distribution and are recommended as the best for planting under English climatic conditions. The number of nuts to the pound is some guide to their size.

Although the large double walnuts *J. regia maxima* variously called *Bannut, Clawnut* and *Noix a Bijoux,* are very attractive and usually sell at a high price, they are not nearly so valuable to the consumer for amount and quality of meat as the " single " varieties named in the foregoing.

(*c*) *English Walnuts specially Selected for Pickling.*

Leeds Castle (*J. regia fertilis* or *praeparturiens*).

Patching (*J. regia fertilis* or *praeparturiens*).

Both these varieties freely bear large clusters of small nuts, which have been approved, after trial, by well-known preserving firms, as being excellent walnuts for pickling.

The seven varieties of English walnuts described above leaf-out approximately one week earlier than Franquette.

II. Other Varieties which are also under Trial.

In addition to the nuts described above some forty varieties chiefly of *J. regia* the scions of which have been collected from many countries are being grown in duplicate

* The number in brackets is that under which the variety was originally sent out.

for trial and study of their potential value under English climate conditions. These trees are of various ages ; most of them have been planted from 3 to 6 years.

(*a*) *French Varieties.*

Parisienne. This is a " Grenoble " walnut, not yet fruited at East Malling, very late in leafing-out in spring.

Chaberte (?) A large nut of good quality, requires plenty of sun to give best results. (It was received under the name of Chaberte, but there is some doubt as to the correctness of this name.) 18-25 nuts per lb.

Vourey. A small roundish nut. 40-50 nuts per lb.

Moraine. Very late in leafing-out. Not yet fruited.

Glady (*J. regia maxima*). A very large double nut, poorly sealed. Not good quality. Very good cropper. 15-20 nuts per lb.

(*b*) *English Varieties.*

Secrett. A large nut stated to be the best English walnut sent to Covent Garden. It is nicely filled with good meat, average 20-25 nuts per lb.

Brandon Hall. Not yet fruited.

Goaman. Not yet fruited.

*J.M.W./P.*12. A good sized nut of excellent quality but sometimes fails to ripen its shell. It may improve with age of tree. 25-30 nuts per lb.

*G.C.M.*1 (*J. regia maxima*). A good promising double nut ; when first received it was badly affected by a bacterial disease, but has remained clean since we eliminated the original infection. 20-25 nuts per lb.

All the above leaf out about the last week in April.

Bensted No. 2 and *No.* 3. Received from Copton Manor, Faversham, Kent.

These two walnuts bore heavy crops of good nuts in the unfavourable season of 1936.

Chisenbury Priory No. 1 (*J. regia maxima*). Received from Chisenbury Priory, Marlborough, Wilts. A very attractive, high quality double nut.

(*c*) *American Varieties.*

Leib Mayette. From Oregon. Similar in growth to French Mayette.

San Jose Mayette. From Nevada City. Foliage thinner and wood not so strong as French Mayette. Nuts of both the above are slightly larger than the French variety.

Franquette. From Nevada City, Oregon. A very good nut, larger than French Franquette.

Treyve. From Nevada City. Nuts very similar to French Treyve, but leaves are flatter and greener. This tree bore excellent nuts in the unfavourable seasons of 1936 and 1937.

The four varieties described above leaf-out late, about the second week in May.

The above are selected seedling individuals from the French varieties of the same name.

Payne. A precocious cropper but poor grower. Too early in leafing-out.

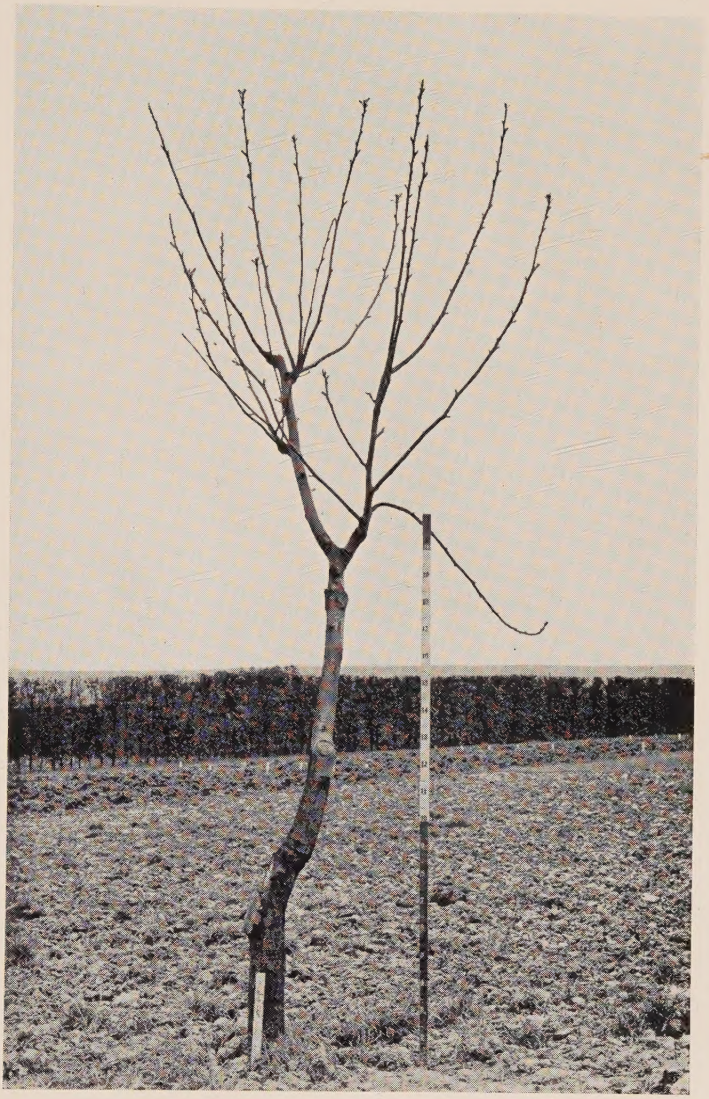


FIG. 1.

A ten-year-old walnut tree with branches budded in May, 1935. Photographed April, 1937.

FIG. 2.

A five-year-old tree which has been summer pruned to induce dwarfness and early cropping.

Alhambra, Lucretia, Grove, Pride of Venturia, Alpine, Ehrhardt, Blackmer, Woodland, Wasson. These have not yet fruited enough to assess their value.

Mammoth (*J. regia maxima*). A large double nut, promising, but needs further trial.

With the exception of the first four these American varieties of *J. regia* leaf-out about mid-April and therefore are unlikely to succeed in our English climate.

Ohio and *Thomas.* These are varieties of *J. nigra* ; they are two of the best Black Walnuts grown for fruiting in the northern parts of the United States, and are used chiefly for confectionery.

(*d*) *Varieties from Various Sources.*

Goliath. From Belgium. A large promising nut. Tree makes very healthy growth. 25-30 nuts per lb. Leafs-out end April.

Persian. From Canada; sent by Professor Blair. Nut very like Goliath. 25-30 nuts per lb. Leafs-out end April.

Sorrento. From Italy. A nice nut, but too early in leafing-out. Leafs-out about mid-April.

Algiers. From Algiers. Not yet fruited. Leafs-out about mid-April.

Cyprus 9. A reputed good walnut from Cyprus. Leafs-out about mid-April.

Gulhak B, C and *D.* From British Legation, Gulhak, Persia (Iran). All good attractive nuts, Gulhak B being particularly good. They leaf-out about mid-April.

III. Varieties for Timber.

The following varieties have been collected on account of their presumed potential value for high-class cabinet work.

Barrington Park (*J. regia*). Parent tree bearing numerous " burrs " of medium size both on main stem and branches. Possibly of high quality timber value.

Kashmir A (*J. regia Koamina*). From the hills of Kashmir. Parent tree has very large " burrs " presumably producing the exquisite burred tracery in the wood so highly valued by cabinet makers. It is not yet known if this quality is heritable.

Lamb (*J. nigra*). A black walnut from New York State with wood of specially good grain, highly esteemed in the United States. This variety is growing well at East Malling. There is every reason to expect its good qualities to be maintained in this country when propagated vegetatively.

Summary.

The work on walnuts, at the East Malling Research Station from 1929 to 1937, is reviewed. Notes on propagation and pollination are given, and a method of producing small garden trees is mentioned. The varieties in the East Malling collection are mentioned and brief descriptions are given of the more important ones.